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The Forest Reserve Situation.

The Government report just issued on the Southern Appalachian and White Mountain watersheds is exceedingly interesting reading. At the last session of Congress an earnest effort, unhappily defeated, was made to secure protection for these important regions. The similar effort at the present session seems likely again to fail, although the forest situation in this country is to-day so serious that it is high time to work consistently for the passage of remedial measures. The question is the old one between the interests

of all the people and the interests of a few. The general situation is clear, but there has been much misunderstanding with respect to details, fostered carefully by those who have to gain by forest destruction or who dislike the present forest reserve administration. Some of these misunderstandings a careful reading of the report under consideration should set right. The situations in the two regions considered vary somewhat. In the Southern Appalachian district the streams fed are to a very material extent navigable and flow through what ought to be, and in places is, rich agricultural country. The damage done by the unrestricted runoff is not only injuriously to affect the hydraulic privileges but to cause, by erosion and deposit of gravel, serious injury not only to the farming land but also to the navigability of the streams.

In the White Mountain region there is in forest destruction the probability of direct injury to streams furnishing something like a quarter of a million horse-power, and also an indirect but peculiarly very serious injury inflicted by the damage of the region as a summer resort country. The White Mountains have been the playground of the Northeast, but many a district has already been well nigh ruined by lumbering and consequent fires. A decade more of such destruction as the last has seen will ruin many a town as a summer resort, including some of those now most prosperous. The actual damage to the water power is hard to measure, since it is in great measure concealed behind large fluctuations from year to year, but those who have made a study of the flow conditions judge that the Merrimac certainly and the Connecticut probably show lower minima and higher maxima than used to be the case. Certainly anyone who has watched the cutting year by year, and has seen the thousands of blackened acres and the mountain sides denuded of everything save rock, realizes that the beginning of the end is here. Missionary work has not been without value and some of the lumber companies have started upon intelligent forestry, yet others still skin the earth and would dig out the very roots could they be profitably sold. Of the damage done some is naturally repaired, yet fires set by accident or in the hope of encouraging a future blueberry crop are so frequent that repair is checked, often permanently, by destruction of the humus down to the rock on exposed slopes. Injury to the water powers will be steadily cumulative throughout this region unless remedial steps are promptly taken.

The situation is grave and yet nothing has been done by Congress to help matters. Something can be done by the States and yet experience has shown that the States move slowly and with uncertain steps. Their legislatures are even more easily handled by the organized lobby than is Congress, and concerted action is very difficult to attain. The present Government forest service frequently causes local disaffection by checking various depredations and the pressure of the defeated spoilers is brought against it. From the common-sense standpoint the States could preserve their forests if they would, quite as effectively as could the general Government, but the States are indisposed to take action and hence if any good is to be accomplished the Government must take the initiative as it already has in many places with good effect. About the only thing that will do good is the establishment of a forest reserve, such as is now under discussion. It probably is not necessary thus to hold a great extent of territory permanently. Sooner or later the States will awaken and will pass reforestation laws and fire laws drastic enough to be of some use. When that time comes they can readily assume much of the forest reserve work. It is perfectly clear, however, that if people wait for the States to act there will be nothing left to preserve. If there is any way in which the long

arm and mighty hand of Uncle Sam can be stretched out and fall upon those who are playing havoc with the just heritage of posterity, let it be done. Surely the preservation of navigable streams and the water powers upon them is not outside the powers of the Government. The trouble is that legislation depends not only on the needs of the country but upon the whims of the statesman-with-both-feet-in-the-trough who should be goaded into some decent sense of responsibility.

Standard Engineering Abbreviations and Symbols.

The Civil and Mechanical Engineers' Society, a British organization, discussed last month the practicability of adopting a uniform system of symbols and abbreviations in engineering work. This is a subject which has long been of interest to those of studious bent, for there is considerable inconvenience in attempting to read articles on certain engineering subjects in which unfamiliar abbreviations and symbols are freely used. In some branches of engineering, custom or the decision of technical societies has established a slight uniformity of notation, so far as English-speaking people are concerned. The lack of any international agreement or custom is evident in every branch of engineering, however, although less difference exists in electricity than in any other single division. There is confusion, speaking generally, even in electricity, and a technical paper on an electrical subject involving mathematical analysis will bristle with so many kinds of letters from modern and ancient alphabets as to look like a display book of a type foundry.

While a simplification of this condition is not a very important thing, it is something worth considering. In these days of innumerable books and society publications, not to mention trade journals, it surely would be a convenience to have some general standard for symbols and abbreviations, not so complete as the international agreement concerning chemical symbols, but sufficiently comprehensive to enable the engineer to understand without too much trouble at least something about the equations which meet his eye on a cursory glance through the pages of a new book. How to bring about such an agreement regarding notation is something of a problem. At the meeting of the Civil and Mechanical Engineers' Society it was noticeable that the symbols which were one man's joy were another man's aversion. Professor Alexander objected to subscript letters while Professor Jamieson claimed that they were extremely useful. On the other hand the latter eminent engineer objected strongly to the use of superscript letters, which, while not common, are employed with every indication of special liking by a few eminent authors of engineering textbooks. Then, again, in the published proceedings of one engineering society the abbreviations for feet, gallons and other terms involving the most common engineering expressions are considerably different from the practice of other equally important organizations.

In this country, the four leading engineering societies, through their secretaries, reached an understanding a few years ago concerning the notation to be used in their transactions, yet it is hard to discover that the abbreviations are consistently used except by the American Society of Civil Engineers. In view of the outcome of this attempt to secure uniformity, it is hardly likely that any very effective agreement toward that end can be reached by individuals, without the influence of technical organizations behind them. As there is a real need for uniformity in notation and in the abbreviations of names of measures, and as most engineering books are written by professors, it would seem as though the Society for the Promotion of Engineering Educa-

tion might accomplish a good deal by taking up this matter. Its members are the leading users of engineering textbooks and are most familiar with the extent to which the simplification and codification of symbols and abbreviations are practicable.

Charges for Professional Services.

The American Institute of Architects is the only professional body in this country which has taken official action to establish to any extent the fees its members shall charge. It adopted a schedule of minimum charges a good many years ago, which has been of much value since then to architects and has been useful in court proceedings and more recently to force the federal government to pay adequate fees for architectural services. Since that schedule was prepared, the cost of conducting an architectural office has been materially increased. Not only has the work to be done become of a higher grade, calling for a greater range of knowledge and experience, more facilities and a wider range of both artistic and structural talent, but the difficulties and expenses of the actual work have been materially raised. The members of the Institute, therefore, appointed a committee a number of months ago to make an investigation of the entire subject. It corresponded with the various Chapters of the Institute throughout the country and obtained from most of them information so complete that it was possible to arrive at a fairly accurate estimation of the condition of architectural work in all the states. The investigation showed a general belief that the rates of the old schedule were too low for work done in the large cities, particularly in New York, that they were satisfactory in most cities, except for plans for residences, but that in the small towns and in the Southern States there was considerable difficulty in securing the fees mentioned. There was a general belief that residential work was unprofitable at the old rates, while the fees for mills, warehouses and manufacturing buildings might be reduced below those in the schedule. In other words, it was found that in the development from the fairly simple conditions of architectural practice of twenty years ago to the complex working conditions of the present time, a need of flexibility in any schedule of minimum charges has arisen. Moreover, the fact was apparent that the Institute could not attempt, with justice to its standing as a professional body, to formulate any absolute rule of charges, like those laid down by a trade union. This last opinion, in fact, was definitely expressed in the introduction to a new schedule of rates which has been sent out to the various chapters for their consideration. This statement reads as follows: "The American Institute of Architects as a professional body, recognizing that the value of an architect's services varies with his ability, experience and the locality and character of the work on which he is employed, does not establish the rates of compensation binding upon its members, but it is the deliberate judgment of the Institute that for full professional services adequately rendered, an architect should receive as reasonable remuneration, therefore, at least the compensation mentioned in the following schedule of charges, and that any variation from the schedule corresponding to a difference in quality and amount of the service rendered may properly be left to individual members or Chapters of this Institute."

Probably nothing that the society could do would be of more value than the adoption of such a statement of opinion. The time has gone by when it is possible to estimate the value of such services by the terms of a schedule except in a very general way. A building designed for

a fussy client and erected in a place not easily reached may be a source of loss to an architect even when the work is taken at a figure which ordinarily would yield him a fair profit. This has been so well recognized that a number of buildings have been built on a cost-plus-fixed-fee arrangement with the architect. Such a system has become so common, indeed, that at the meeting of the Institute at which the proposed changes in the schedule were discussed, the adoption of such a system was suggested. It did not meet with favor, although it might be distinctly to the client's advantage in some cases and might improve the conditions under which the architect worked in other cases, because the supervision of the expenses and management of the architect's practice by the client might introduce too great complications to be practicable. The proposed schedule is intended to indicate the minimum charges on which an architect can prepare plans and specifications and supervise the construction of buildings at a reasonable profit to himself. It differs from the old schedule in suggesting higher fees for works of small extent or highly responsible nature, demanding as much time and ability as works of much larger extent. It further provides that professional fees shall be charged for advice in proportion to the importance of the question involved and the services rendered, a modification of the wording in the old schedule.

These are changes for the better, for it goes without saying that a professional man should be paid for what he does. This feeling is at the root of the proposed changes and is the same belief that frequently finds expression in engineering practice. This journal is often asked to suggest the proper charges for certain classes of engineering services. This is a difficult question to answer, for the value of the services depends very largely upon their nature, which often is unknown. For example, if an engineer is employed to design the mechanical installation in a building of moderate size, and conscientiously prepares plans and specifications for all of the work, leaving none of it to the contractors, he may find that the cost to himself of the work and its supervision exceeds 10 per cent., which is the ordinary fee for such services. Moreover, one architect or engineer will be able on account of his special knowledge or special office organization to carry out an engagement at much less cost than another, and consequently his profit at the same fee will be much more. For this reason The Engineering Record has always felt that the value of such a schedule of charges as that of the American Institute of Architects is not so much to the architects as to the public at large, by fixing in a fairly definite way the minimum fee which should be paid for professional services. Viewed in such a light, a schedule is a public benefit. It should indicate to the intelligent client that any attempt to obtain services at a lower rate will probably result in his reliance being placed in an incompetent man. It will further indicate that if a client wishes the services of a man of the highest standing, he must pay far more than the schedule indicates. And when the schedule is prefaced by such a statement as that quoted in the introductory paragraph, it becomes a useful document to the architect on certain occasions, when the nature of the work to be done is comparatively inexpensive for his organization, since he can charge a fee less than the minimum rate and at the same time obtain a reasonable compensation, without in any way transgressing any professional rules of the Institute. When viewed in the light of a guide rather than a law, such a schedule has everything to commend it and should prove of much value, as has been shown by long experience with such schedules for engineering and architectural services in Germany.

Engineering Education.

The real importance of any subject is fairly well indicated by the attention which those in interest give to it. Measured by such a standard the importance of technical education is scarcely second to that of any subject which interests the engineer. There probably is not an influential engineering organization in this country which has not given serious consideration of late to its educational qualifications for membership, and some of them have discussed the subject a number of times. More than that, a large and influential society has been created for the promotion of engineering education solely. The last prominent engineering society to take up this much discussed question is the American Institute of Electrical Engineers which devoted a special meeting on Jan. 24 to the consideration of better education for electrical engineers, which obviously is but a part of the general problem of technical education.

There is one feature common to all these discussions which at first sight seems most unfortunate, and that is the great variety of opinions expressed as to the fundamentals which should underlie the educational training of all engineers. This observation is about as true of the judgments expressed by engineering educators as of those set forth by practitioners. Doubtless the origin of this feature of the matter is to be found in the comparative newness of the whole work of instruction in engineering, although it is much accentuated by the great variety of individual experiences. One engineer is made to feel keenly the lack of certain knowledge of principles or information as to practical details in some part of his own work. He immediately reaches the conclusion that one of the most important parts of an engineering school should be instruction in just those lines where he has been weak. Another engineer has a similar experience in some other line of practice and he at once reaches the same conclusion as to the duty of the engineering school in respect to that of which he has most felt the need. And so on throughout the scale. There is probably no engineering instructor of extended experience who has not had just such matters brought to his attention most earnestly many times.

Engineering education, like many other broad fields of work, rests upon certain general fundamental principles which should govern its development and administration. The purely professional part of engineering work is founded upon certain portions of physical science which, when acquired by the student, give him educational training in what is known as engineering science and which obviously he can learn only in the engineering school. These physical principles lie at the basis of all his professional engineering work and his grasp of them should be comprehensive and most thorough, whatever his special field of practice may be in after life. In this part of his educational training, analytic and laboratory work should be carefully developed in suitable co-operation. The principal functions of the engineering school are to be discharged in this part of the curriculum. The last year or year and a half of the engineering student's work should be characterized by such judicious applications of these fundamental scientific principles to the actual problems of the engineer as can be made in the engineering school. These exercises should be taken under the direction of instructors who have had actual engineering experience. The time has passed when engineering instructors could qualify themselves for their work by close operations. Obviously instructors should be students in the highest and best sense of the term, but it is absolutely essential at present, and it will always remain so in the

future, that reflections of the study should be supplemented by actual work in the office and field.

At this point, however, lies a serious danger in engineering education. The word "practical" has done far more damage to the cause of true engineering education than the word "theoretical." It has long been the fashion with some to use the latter term contemptuously as indicating mere book learning, whereas engineering theory simply means the ground-work of real knowledge, which is absolutely essential to the effective solution of the most difficult engineering problems and the only basis of rational design. Again, many engineering instructors think that if they call certain operations practical, they will somehow acquire value not otherwise possessed. Further than this, it is not uncommon to find practitioners discussing certain features of engineering education as not being sufficiently practical, meaning that the instruction ought to be devoted much more to the daily technique of the office or the routine details of work in construction. All this is wrong, and it is one of the most gratifying features of such discussions as those under consideration to find, as time goes on, that these crudenesses are largely disappearing.

It should be recognized at the outset that no engineering school can turn out a complete or finished practitioner. That is not the purpose of such a school. The object of engineering education should be the educational training of a young man in the fundamental principles of engineering science and in such applications of it to engineering problems as will enable him after graduation to become a satisfactory practitioner within a reasonable time, and that is all the technical school can and ever will accomplish. The development of a well trained judgment and the acquisition of capacity to administer in an efficient, executive manner the large and complicated interests of great enterprises, or the creation of organizations of which the handling of men is one of the most important duties, must inevitably follow or result from experience with affairs during a period of greater or less number of years. No institution can confer such qualities upon its students and the attempt to do so will result in failure. The time devoted to such ill-directed efforts could much better be applied to perfect and render more efficient the instruction peculiar to the technical school, which the young engineer will never get anywhere else.

The most serious defect of engineering schools at present is their intense specialization. It would be far better if much more attention were given to instruction in the fundamental general principles underlying all engineering, precisely as do law and medical schools. Engineers should be well educated professional men and thereby they would become more effective specialists. This is precisely in line with the expressions of some of those who joined in the discussion at the meeting of the American Institute of Electrical Engineers. Indeed, some of the expressions made at that time went so far as to advocate a liberal course of study as a preparation for the technical course, as is now required at Harvard University, which again is a most encouraging indication for the broad subject of the educational training of engineers.

Notes and Comments.

PANAMA CANAL EXCAVATION during January reached the largest total since the work began, the amount officially reported being 2,712,568 cu. yd. Of this total, 2,488,039 cu. yd. were taken from the canal prism. The increase in excavation occurred in every division of the work, and in the Culebra division 1,150,334 cu. yd. were removed, the largest record made there. About 70 steam shovels were available for use during the month.

THE NEW CANADIAN TRANSCONTINENTAL Railway under construction from Moncton on the Atlantic coast to Prince Rupert on the Pacific has been pushed so vigorously, according to U. S. Consul Seyvert, that the prairie section will be completed very soon, and before the close of this year the 794-mile section between Winnipeg and Edmonton will be in operation. Rails have already been laid on 322 miles of the road that is being built by the Grand Trunk Pacific Ry. Co., and on 75 miles of the part under the charge of government commissioners. The latter have 955 miles of their section under contract. The most difficult work will be between Edmonton and Prince Rupert, and will be begun during the coming spring. About 25,000 men have been employed on this work, and it is expected that it will be finished late in 1911.

THE RAILWAY ELECTRIFICATION in Austria which was mentioned in this journal some time ago, owes its importance, according to Freiherr Von Ferstel, of the State Department of Railways, to the constantly increasing price of coal, which makes it extremely difficult to operate railways in the Alpine districts at anything like a profit. According to his statements it now costs something like \$1.75 to pay the cost of transporting the coal to the Arlberg section of the State Railways. In view of this fact, and also on account of the rapid appropriation of water powers by private corporations for industrial purposes, steps have been taken to secure control of enough power rights to furnish the necessary energy for the Alpine railways. During the past year the government has made an examination of all the water powers west of Salzburg and it is proposed to make surveys in other districts during the current year so as to ascertain what water power can be used for other railway lines.

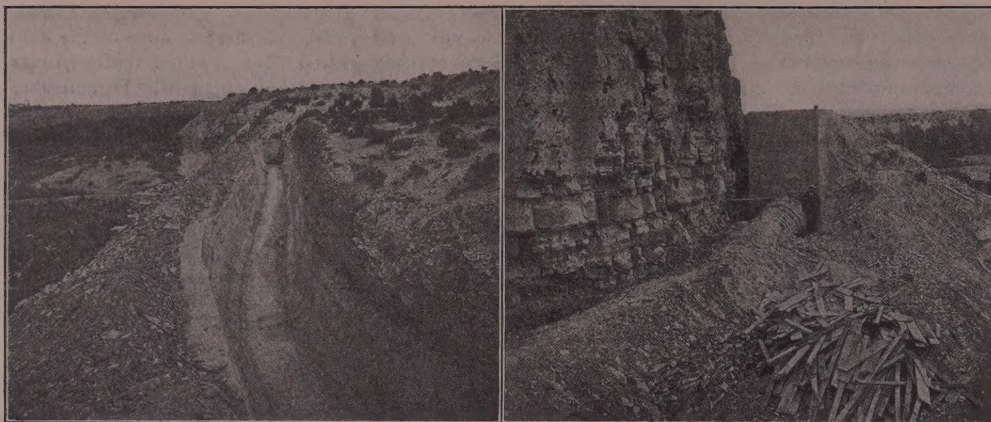
THE LAWRENCE AVE. CONDUIT of the Chicago intercepting sewerage system is now rapidly approaching completion and in a short time it is probable that the waters of Lake Michigan will be passing through this conduit, flushing the sewage of a large section of the North Side of the city toward the main drainage canal. This work was undertaken about the same time as the 39th St. conduit, and a description of it was published in *The Engineering Record* of April 9, 1898. From the beginning there has been a succession of difficulties attending the execution of the work. In this journal of Aug. 12, 1899, there appeared a description of an interesting excavating shield which was tried on the tunneling, but this proved unsuccessful like many other things which were tried at one time or another. At the present time the tunnel running out into Lake Michigan has not yet been completed, but it is expected that this will be finished by the end of the summer.

MINE FIRES are a source of such great losses that the Technologic Branch of the U. S. Geological Survey is rendering valuable service by the investigation it now has under way to determine the best methods of fighting such fires. At the meeting of the American Institute of Mining Engineers this week, Mr. W. O. Snelling reported that these investigations indicate the practicability of employing sulphur dioxide in combating underground fires. The use of carbon dioxide has been tried successfully a number of times, but the gas costs about \$4,000 per million feet, made by the action of sulphuric acid on limestone, while sulphur dioxide can be made for half that sum, according to Mr. Snelling. He also stated that sulphur dioxide is much more effective than carbonic acid gas in putting out a fire. No combustible can burn in an atmosphere containing much of it, and as it weighs twice as much as carbon dioxide it will find its way more efficiently into all parts of a mine. Moreover, none of the dangers incident to the use of carbon dioxide

occurs with sulphur dioxide; no explosive lower oxides are formed, and there is none of the danger existing with carbonic acid gas that men may get into its atmosphere unknowingly and thus suffocate. A small fraction of one per cent of sulphur dioxide in the air is indicated by its pungent odor.

THE FOREIGN COMMERCE of the United States during 1907 is reviewed in some figures sent out by the Department of Commerce and Labor which are interesting as showing the shifting in the export and import trade of the various sections of the country during the last ten years. The Atlantic Coast ports which exported 70 per cent. of all the goods sent out of the country in 1897 exported but 60 per cent. of the total in 1907, while the percentages of exports through the Gulf, Mexican border and Canadian border have materially increased. During the ten years the value of exports through the Gulf ports has shown a gain of about 140 per cent., and Galveston is now the second largest exporting city of the United States. The value of merchandise exported through the Atlantic Coast ports increased 50 per cent. during the ten years, while the other ports of the country show an average increase of 131 per cent. In the matter of imports, the Atlantic ports show a much larger volume of business, amounting to 80 per cent. of the total in 1907. The value of the merchandise imported through them increased 80 per cent. in the ten years ending on Dec. 31, 1907. The amount of business done in 1907 by the large ports was as follows: New York, exports, \$683,000,000, imports, \$830,000,000; Boston, \$105,000,000 of exports and \$123,000,000 of imports; Philadelphia, \$81,000,000 of imports and \$107,000,000 of exports; Baltimore, \$36,000,000 of imports and \$98,600,000 of exports; Galveston, \$197,000,000 of exports and \$7,700,000 of imports; New Orleans, \$44,000,000 of imports and \$165,000,000 of exports.

REINFORCED CONCRETE for buildings recently received a most favorable commendation from the Royal Institute of British Architects. Last summer the British Office of Works requested the Institute to express an opinion concerning the durability of reinforced concrete buildings, for at that time the Local Government Board was contemplating making certain discriminations against this material as compared with brickwork. In its answer, the Science Standing Committee of the Institute stated that works in reinforced concrete which comply with the requirements outlined in the report of the committee printed in *The Engineering Record* of Aug. 3, 1907, are at least as durable as brick or stone buildings. The committee stated that any action which would limit the period of loans for reinforced concrete work to less than the period for brickwork would be a mistake, resulting in Great Britain being largely debarred from the advantages of modern and more economic methods of construction employed, not only by foreign countries, but by bodies not requiring the consent of the Local Government Board to their undertakings. The committee further pointed out that after the great chain tie which binds the base of the dome of St. Paul's Cathedral had been in place for more than 200 years, it was examined and found perfectly bright, owing to its protection by the concrete in which it had been embedded. It is further pointed out that in 1886 the city of Grenoble constructed some reinforced water pipes which were in service for 15 years without any cracks appearing. They were then examined and the metal of the reinforcement was found to be entirely free from rust although the pipes had been under a head of many feet. The results of these examinations and other information of the same nature convinced the committee that reinforced concrete, when properly made, is a thoroughly reliable material.



A Section of Lined Ditch.

Head of an Inverted Siphon.

AN UNUSUAL WATER SUPPLY FOR INDUSTRIAL PURPOSES.

The Minnequa steel works of the Colorado Fuel & Iron Co., at Pueblo, Colorado, is one of the largest industries west of the Mississippi River, embracing six modern blast furnaces, several large mills producing steel rails, structural shapes, wire and other steel products and employing 5000 to 7000 men. The iron-ore supply is obtained from extensive mines in Wyoming, New Mexico and Colorado, and is shipped to the works by rail. The coal-mining and coke-making operations, of the company in the Trinidad district, in southern Colorado, in which district the coke required to operate the blast furnaces is made, were fully described in The Engineering Record of December 14, 1907. Limestone of excellent character, is obtained from quarries adjacent to the works. Although unlimited quantities of iron-ore fuel and limestone are thus made available in an ordinary manner, the provision of a cheap and abundant supply of water, which is as fundamental as any of the materials, has been provided only by the construction of works of very unusual extent and magnitude.

The steel works require from 30,000,000 to 50,000,000 gal. of water a day, but only a portion

State laws of Colorado favor appropriation for domestic, sanitary and irrigation purposes over those for manufacturing uses, in order to obtain water for industrial purposes during low flows, rights antedating the constitution of the State would have to be obtained. Such rights are scarce and exceedingly valuable in the intensely irrigated regions dependent on the river for water.

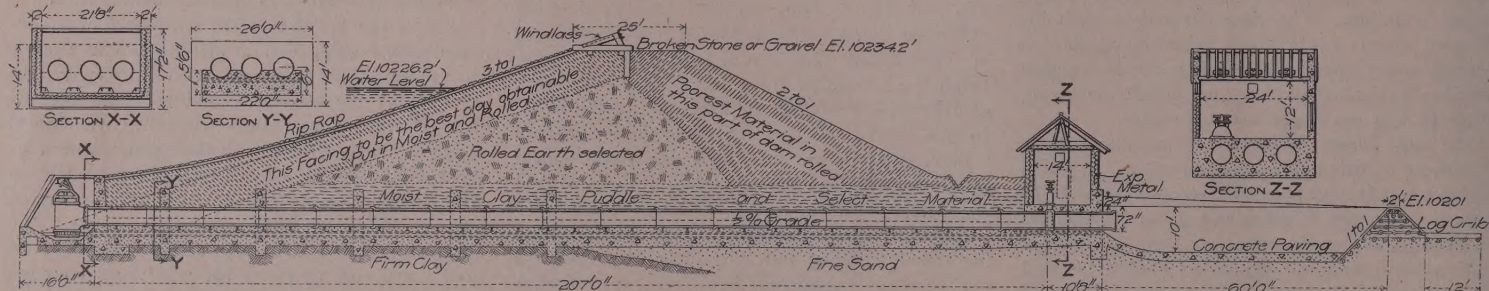
On the other hand, in this region it is not often possible, nor within reasonable cost to build dams on the main streams, added to which limitations is the danger to life and property in the valley below offered by a dam so situated. At the same time, suitable sites for reservoirs of much capacity, located out of the main stream valleys, where storm waters can be conducted to them from the streams by canals, and also piped from them by gravity to the works, are very limited. Furthermore, to depend on storage for a daily consumption of over 50,000,000 gal. in a country where droughts of a year's duration have to be considered, where evaporation from a water surface reaches as high as 1 ft. in thirty days in the summer, and where, owing to the character of the ground, seepage is known to be large,

stream. Other extensive reservoir sites in the same locality in which flood waters may be stored also exist.

The flood storage system is supplemented by various ditch rights in the Arkansas River, which rights furnish considerable water during other than flood periods. Although the ordinary flow of the river is fully appropriated, the Colorado laws permit water impounded during floods to be returned at any point in time of drought and then taken out at a point farther downstream, after a certain percentage has been deducted for evaporation and seepage. The supply made available for the works by the combined prior rights and flood-water storage system in operation is, therefore, under the existing conditions, not only adequate for the present, but also provides for future growth.

Two of the first reservoirs built are at some distance from the steel works, near the St. Charles River, and are utilized chiefly for storage. A canal, six miles in length, extends from a head-gate on the river, seventeen miles from the steel works, to both of these two reservoirs and to one of those used for receiving and distribution. The head-gate is a concrete structure at one end of a low concrete diverting dam built on bedrock. This canal is 25 ft. wide on the bottom and has a capacity for carrying 600 cu. ft. of water per second, the head-gates being arranged to divert that amount under certain flood conditions. The canal follows along the bluffs of the river and then passes through a heavy cut in a divide between the catchment area of the latter and of another stream, called Salt Creek, in the valley of which the reservoirs are located. Much difficult work was involved in the construction of the canal, as part of the excavation was in rock and several gulches had to be crossed by inverted siphons.

Each of the siphons consists of a pair of 6-ft. wood-stave pipes, which were laid below the ground surface where waterways are encountered. At each of the siphons the canal was brought to a convenient point on one side of the gulch and terminated in a concrete forebay basin of the general type shown in one of the accompanying illustrations. The sides of these basins are built on converging lines and the bottom is on a consider-



Cross Section of Dam at Sugar Loaf Reservoir.

of this is evaporated or used in making steam. As the remaining quantity is largely utilized for cooling the furnaces, condensers, rolling mills and so forth, it is returned to the streams practically uninjured for other purposes. The climatic, topographic and other conditions existing in the region in which the works are located, however, render the provision of a supply of this magnitude very difficult and expensive. The region is on the eastern slope of the main range of the Rocky Mountains, where the mean annual rainfall is not more than 14 in. and the evaporation is excessive.

Two means of obtaining a water supply in this region exist, one by diverting it from the streams, which have their head waters in the mountains, and the other by the conservation of flood waters. The steel works are close to the Arkansas River, the principal stream in that section of the country, but the waters of this river, including considerable flood flows, have long been appropriated for irrigation purposes and other uses. As the

would mean the construction of a large number of reservoirs of immense capacity. The value of the prior rights in the river and the advantage of a gravity supply such as is obtained from storage reservoirs make it essential, however, that a combination of the two sources be made in order to obtain the required amount of water.

The water-supply system of the steel works is derived partially from the watershed of the St. Charles River, a tributary of the Arkansas River, and partially from the watershed of the latter. The developments on the watershed of the St. Charles River were the first to be made and embrace a series of three large storage and receiving reservoirs, two of which are supplied by storm waters from drainage areas tributary to them, or by flood flows conducted to them from the river by a large canal, and the third by this means and also by water rights in the river. The present development of the system on the Arkansas River consists of a single large, storm-water impounding reservoir on the headwaters of that

able slope; the two 6-ft. pipes which form the siphon have their upper ends imbedded in a wall across the end of this forebay, with their inverts flush with the bottom of the latter. The pipes are enlarged adjacent to this forebay, and as the sloping bottom of the latter brings their open ends several feet below the water surface in the canal, they are fed under pressure. The two siphon pipes terminate in a similar concrete structure on the opposite side of the gulch. The difference in elevation between the canal on the two sides of each gulch where a siphon is required is sufficient to produce a high enough velocity in the pipes to carry all the water the canal can bring to them, and to prevent the deposition of mud, sand or gravel. The pipes are also large enough to carry a sheep, a horse, tree trunk or other large drift liable to be brought down during floods, which is practically the only time the canal is in service. When the canal is dry, the siphon pipes are arranged to stand full of water, in order to keep the staves wet.

One of the two storage reservoirs has a capacity of 2,000,000,000 gal. and was developed by an earth dam 5000 ft. long, 40 ft. in maximum height, 20 ft. wide on top and with a 2 to 1 slope on the downstream side and a 3 to 1 slope on the upstream side. The second reservoir has a capacity of 1,500,000,000 gal., and was also developed by an earth dam of the same general cross section as the former, but is 4,000 ft. long and has a maximum height of 25 ft. The water from both of these reservoirs is carried by gravity to one of the two from which it is supplied directly to the works. This first distributing reservoir has a capacity of 550,000,000 gal. and also receives some water directly from the St. Charles River by a ditch right. A 28-in. wood-stave pipe line, $4\frac{1}{2}$ miles long, extends from this reservoir to the steel works and delivers water to the latter at a pressure of 150 lb. per square inch.

The other distributing reservoir is used for emergency or reserve purposes. It is within a mile of the steel works, and 50 ft. above the latter, but receives only the surplus from the main distribution reservoir. A separate 28-in. supply

back to the summits of the mountains 14,000 ft. or more in height, on which, in the gulches and timbered slopes, much snow exists perennially.

The average annual rainfall at Leadville is 14 in., but the catchment area of the reservoir being on the west side of the valley, has been observed locally to have more rainfall in summer and more snowfall in winter than occurs at Leadville. The records of the run-off from the drainage area show a maximum flow of 600 cu. ft. per second in June, and a minimum of 6 cu. ft. per second in October, the minimum continuing until the snow on the mountains begins to melt in the following May.

The site was surveyed by the United States Geological Survey in 1891-92, with the idea of building a Government reservoir. This project, afterwards abandoned, contemplated a dam to impound 50 ft. of water, which would have covered two practically distinct reservoir sites connected only by a narrow neck. Owing to difficulties involved by raising the water level to that extent, the decision was made to erect a dam to impound 30 ft. of water. The reservoir created by

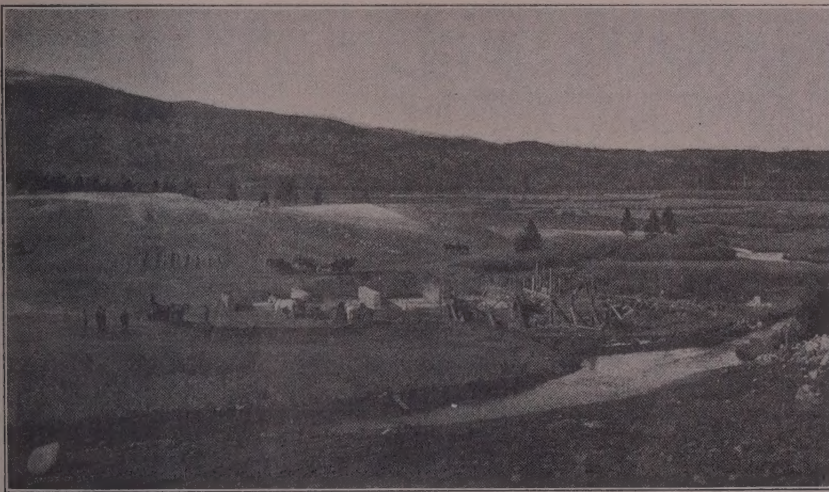
that immense damage would result below in case the dam was overtopped and carried out. Extreme means of providing an outlet for the water were, therefore, provided, consisting of three 48-in. cast-iron pipes laid through the dam on a 0.5 per cent grade, and a total spillway crest of 400 ft. The spillway precautions which have been taken may appear extravagant, but are believed to be fully justified by the damage which would result from a failure of the dam. Since the greatest known flood during the season of melting snow is 600 cu. ft. per second, any length of spillway based on this flow, or on an assumed rainfall and run-off would require much less capacity than has been provided. The amount of spillway capacity obtained was, as a matter of fact, as great as permitted by a reasonable cost, and since the excavation from the spillways was utilized in the dam, this cost was nominal.

At one end of the dam a favorable location existed in ground composed of clay and boulders where a level-crest excavation, 200 ft. long, was made at the high-water level in the reservoir. On the downstream side of this crest a 1 per cent grade on the surface slopes into a natural hollow discharging below the dam. This part of the spillway has been paved with rip-rap as a precaution against wash. To the hill side of and adjoining the 200-ft. of spillway an additional 100 ft. was excavated at a level of 2 ft. higher. At the other end of the dam an excavation 100 ft. wide at the same upper elevation was also made.

The three lines of 48-in. pipe are each capable of carrying 400 cu. ft. per second when the reservoir is full, and the flooded area is 818 acres at the 30-ft. depth. The top of dam is 8 ft. above high-water line. From this it is seen that the three lines of pipe alone more than suffice to carry any ordinary flow, as the usual spring melting of snow produces about 350 to 400 cu. ft. per second and at such times the reservoir is being filled. Should the water from any cause rise 2 ft. above high-water mark the spillway would then carry a sectional area of 400 sq. ft. and an additional 2 ft. would add 800 sq. ft. to this, or 1,200 sq. ft. in all. This would give a discharge capacity, added to the pipes, aggregating in all over 7,000 cu. ft. per second, or more than ten times the greatest known flood, and this level would still be 4 ft. below the top of the dam.

The entire area of the dam site was overgrown with willows and some trees, and in the lowest portion, adjoining the stream, was covered with 1 to 2 ft. of black muck. All this had to be removed, the roots grubbed out and the top soil skimmed off. The latter was done by a light plowing and was handled with slip scrapers. The surface was then benched or furrowed. The channel of the stream was diverted to one side, and excavation made for a pipe cradle, or concrete base for the outlet pipes.

This excavation was first stripped of vegetable matter, roots and muck and the underlying clay sheet exposed to about the longitudinal center line of the dam, where it thins out into sand of unknown depth, as shown in the cross-section of the dam. The trenches for five transverse cut-off walls, about 21 ft. apart, were excavated 2 ft. deeper and wider than the balance of excavation, to more effectually check any flow of water along the surface of the concrete. The base of the cradle consists of 48 in. of concrete composed of the most compact mass that could be made with the sand, gravel and small boulders existing in the vicinity of the site, determined by experiment for each kind of aggregate used. Both sand and gravel were from granitic formations and excellent in quality, although the sand was rather fine grained. Seven lines of 85-lb. steel rails were placed longitudinally about 3 ft. apart, and cross rails, 6 ft. apart, were set over these in the concrete. On this grillage of rails the three lines of 48-in.



Sugar Loaf Reservoir Dam under Construction.

line is, however, extended to the works from it. This arrangement of reservoirs is followed because the reserve reservoir, although it has a capacity of 450,000,000 gal., is quite broad and shallow, thus offering a large surface for evaporation.

Although the four reservoirs referred to and the water rights in the river provide a large supply, in order to create a reserve supply that would insure the ability to withdraw from the river into a conduit leading to the reservoirs near the works at Minnequa the amount of water represented by certain rights, and to provide for future needs, the impounding reservoir on the headwaters of the Arkansas River has been built. The design and construction of this reservoir were described in considerable detail before the Western Society of Engineers by Mr. R. M. Hosea, chief engineer of the Colorado Fuel & Iron Co., and from that description the following notes have been taken.

The reservoir is on the Lake Fork of the Arkansas River, five miles west of Leadville, Colorado, and over 170 miles from the steel works, by way of the river. The site is the bed of an ancient lake at the base of Sugar Loaf Mountain, a spur of Mt. Massive, one of the principal peaks of the Saguache Range of the Rocky Mountains, bordering the Arkansas River on the west for 50 miles. The mountain slopes in the vicinity are well timbered with second-growth spruce, pine and balsam, and are generally covered with grass. The reservoir is at an elevation of about 10,000 ft. above the sea, and as a consequence the snow does not begin to melt in any considerable volume until June. The drainage area tributary to the reservoir is between 25 and 30 square miles, reaching

this dam covers 818 acres and contains 6,000 million gallons of water when filled. Later, if it is shown that the available supply will justify additional storage, by erecting a dam across the narrow neck between the two reservoirs to impound 20 ft. of water, an area of 350 acres can be flooded and a lake containing 2,500,000,000 gal. created.

The valley at the site of the dam was originally closed by a glacial-deposit of clay and boulders, through which the stream had broken. The ancient lake bed forming the reservoir site is underlain wholly, or partially by a clay sheet, 4 ft., or more thick, which also extends partially under the dam. The material in the moraine, on the hill-sides and in the vicinity generally, was a clay, sand and boulder mixture of a nature extremely favorable for dam construction.

Borings at the outer, or lower half of the dam showed the stream bed at that point to have an underlying deposit of fine sand of unknown depth and indicated that the clay sheet should not be penetrated by any sheet-piling or core-wall construction in the body of the dam. On the other hand, this deposit rather favored the making of a juncture with the clay sheet below by a clay lining of sufficient thickness and suitable construction placed upon the inner, or water face of the dam. The dam was accordingly built entirely of the material adjacent to the site and of the cross-section shown in one of the accompanying illustrations.

Although cloudbursts on the eastern slope of the mountains are frequent, conditions in the immediate vicinity make them unlikely at the dam. The location of the reservoir is such, however,

extra-heavy cast-iron pipe, with lead joints, were laid 7 ft. apart on centers. The pipes were then bedded in concrete up to their horizontal center lines and the top surface of this concrete left quite rough and irregular. The transverse cut-off walls were carried up 4 ft. above the tops of the pipes and projected 2 ft. beyond the sides of the cradle excavation into solid ground. After the forms had been removed, the best clay available was wet and tamped by hand above and around the structure for 4 to 5 ft. This clay was of a grade similar to Potter's clay and made a splendid puddle. It was blended at the top with the next best material available from the excavation. Work on the main part of the dam to one side of the diversion channel was started meanwhile, and was extended as far as feasible toward that channel. The spillways were first excavated and this material, exclusive of large boulders, was placed in the downstream part of the dam section. Borrow pits were laid out on the inside of the reservoir site over a large area and stripped of all vegetable matter, exposing the sandy clay mixture, which contained some boulders, and beneath which was the clay sheet 4 ft. or more thick. The dam then was carried up in thin layers by depositing the clay on the inside face to a thickness of 20 ft., then the next best material, and so on to the outside, where the poorest material was used. The whole was smoothed, sprinkled and rolled with a heavy Springfield roller blending all together, the formation of layers being carefully avoided, by depositing loads irregularly.

After the base of the dam was built, it was found best, both for economic results and speed, to have the contractors install a small steam shovel and load into dump wagons, taking the moraine material from a spur or extension into the flooded area, which furnished ample material for finally closing the gap in the dam when the low-lying borrow pits were flooded by the rising of the water in the lake. Grading machines were tried for a time, but the presence of boulders in borrow pits made their use inadvisable, and it was found more economical to load directly from the dipper of the steam shovel into dump wagons, which, with a little care, was done without undue wear and tear on the wagons. The accompanying cross-section shows the manner in which the different materials were blended together to form the dam prism, except the filling in around the pipe and cross-walls done by hand, as explained.

The boulders from the spillway and borrow pit excavation and from the slopes of the adjoining hills were hauled to the dam and the rip-rap facing carried along concurrently with the progress of the work on the dam. The amount and quality of this work is of prime importance at this locality, as there is an exposure of about $1\frac{1}{2}$ miles to form waves and the formation of ice on a full reservoir in winter is considerable. Owing to the sheltered locality, however, and the direction of prevailing winds, the wave action is not so great as might be expected. The ice forms sometimes over 36 in. thick, but usually melts quietly and thus far has shown little tendency to dislodge the paving.

The rip-rap is laid in three zones, a lower one resting on a base at the toe of the slope with a maximum and minimum thickness of 15 in. and 10 in., respectively, a middle zone with a maximum of 12 in. and a minimum of 8 in. extending to a flow line, and an upper zone with a maximum of 6 in. and a minimum of 4 in., extending to the top of the dam. These merely indicate the quantities that were paid for, as the material composing the rip-rap is glacial boulders and fragments of broken boulders and the actual thickness as laid is greater. The boulders were laid to a fairly smooth top surface supported on smaller stones

where necessary and chinked with spalls, with the sides running the long way of the dam and ends breaking joints on the slope.

A concrete inlet basin was built around the ends of the pipes at the toe of the inner slope of the dam. This basin consists of a concrete back wall, in which the ends of the three pipes are imbedded and two side wing walls, with a concrete bottom between them, all reinforced with expanded metal. The back wall forms part of the concrete cradle supporting the pipes and extends below it to serve as a cut-off wall. In the same manner, the wing walls and a wall below the front end of the bottom are placed well into the clay to cut off any flow due to the 30-ft. head when the reservoir is filled. The front and top of the basin are covered with a screen of iron bars to keep out drift and debris. The bars at the front are inclined and are arranged with the horizontal bars over the top so they present a smooth surface from which the drift can be raked when they are submerged.

The basin contains three 48-in. balanced valves, one controlling each of the outlet pipes. These valves are of special design and consist essen-

tially of two discs mounted on a vertical piston carried in a special tee-joint at the end of each pipe; these discs seat in the upper and lower ends of this tee. The operation of each valve is controlled by a chain which extends up the face of the dam in a trench in the rip-rap on the latter.

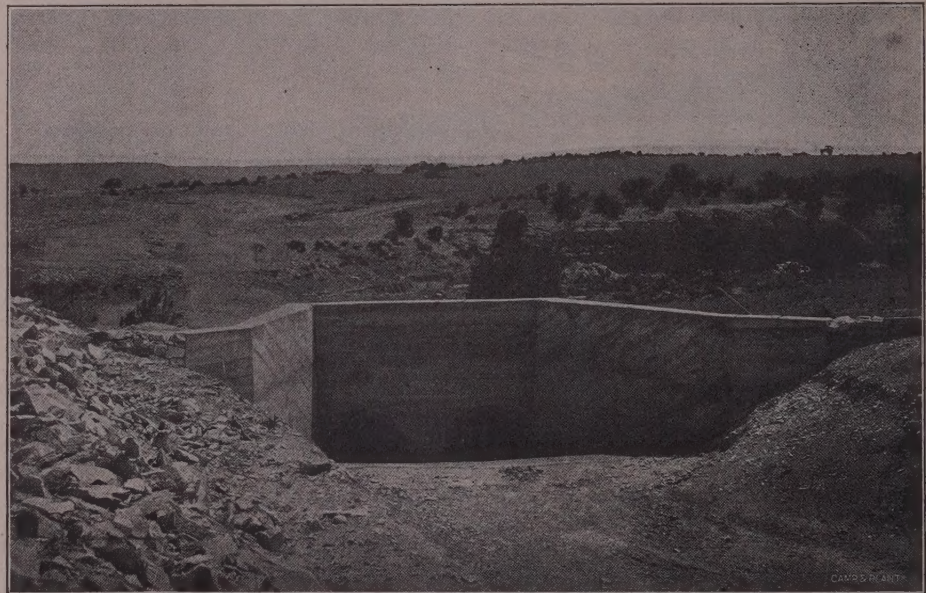
The flow through the outlet pipes is also controlled by three Rensselaer geared valves in a concrete valve chamber built on the downstream end of the cradle carrying the pipes through the dam. The walls of the valve chamber are reinforced with expanded metal, the ceiling being covered with a corrugated-iron roof. This style of construction was better and cheaper than brick in the locality and was adopted to protect the valves against freezing at the altitude of over 10,000 ft. Provisions are also made in the valve houses for a stove and for banking material around the valves, if necessary in extreme cases.

To further guard against frost, the outlet basin is constructed as shown by the drawing, with a concrete-lined bottom and three sides of log cribbing filled with rock and sand and double-sheeted with Burnettized plank, with a caulked oakum joint where it abuts against the end wall of the pipe cradle. This construction maintains a water cover of 2 ft. over the ends of the outlet pipes at all times and prevents frost from entering the ends of the pipes and reaching the valves. The basin serves also to retain the fish and

to spread the outflow of water into a thin sheet falling over the three sides of the basin to the apron outside; thence it can run quietly to the stream below.

The total quantity of excavation made in building the dam was 114,363 cu. yd., of which 96,762 cu. yd. came from the borrow pits and the remainder from the spillways. Of this amount, 17,475 cu. yd. of top soil were wasted and 1,500 cu. yd. of stone were used for rip-rap, leaving 95,000 cu. yd. of excavation actually put into the dam. The actual volume of the dam, from cross-sections, shows 90,200 cu. yd. of material, indicating a shrinkage of 5.44 per cent. The estimated cost of the dam, including the site, lands, materials, labor and engineering, was \$127,655, and the final cost was slightly within that amount.

The dam was built by Messrs. Clough & Anderson, of Colorado Springs, under the direction of Mr. R. M. Hosea, chief engineer; W. M. Porter, assistant chief engineer, and W. D. Slater, resident engineer of the Colorado Fuel & Iron Co., and Mr. John Birkinbine, of Philadelphia, consulting engineer.



Inverted Siphon Forebay on St. Charles River Flood-Water Canal.

The water after leaving the dam flows for 130 miles in the natural stream channel before it is diverted into a conduit 42 miles long leading to the distributing reservoir at the steel works. This is done under the laws of the state, which provide for the storage of waters in time of floods, which waters returned to the streams at later periods may be withdrawn at points below, as already explained.

The water is diverted from the river into the conduit by a low concrete dam with head-works in one end from which the flow is controlled. The conduit is designed to carry 100 cu. ft. per second, and is arranged to deliver to one of the two reservoirs near the steel works used for storage only, or to either of the two distribution reservoirs. These reservoirs are 40 miles from the diverting dam at the head of the conduit, and are to one side of a direct line from the steel works to the dam, the works and diverting dam being 42 miles apart. The conduit consists of 12 miles of 48 to 60-in. wood-stave pipe and 28 miles of ditch, which includes 2,000 ft. of tunnel. A 5-mile wood-stave pipe line was also built from the reservoirs to the works as a part of the conduit. The ditch sections are lined with concrete where poor soil was encountered, but are lined with earth where practicable.

The construction of the conduit was one of the most difficult projects of the kind that has been undertaken in the West, owing to the character

The piles are designed to be driven very close

The Treatment of Concrete Surfaces.

A paper read before the National Association of Cement Users by E. B. Green, Architect, Buffalo, N. Y.

I need not tell you that the architect's interest in the uses of cement is second only to your own. But while you are enabled to give your entire time and thought to cement construction, his interests are necessarily divided among many methods of construction and various materials. When you think of the various things that enter into the construction of a modern building, of which he must have more than a passing knowledge, and to no one of which must he give an undue weight, it will appeal to you that the interest which he takes in concrete construction must be somewhat less than yours. He can not pretend to become an expert in any one method of construction, and it therefore gives us pleasure and much profit to become acquainted and be surrounded with those who devote their efforts and intellectual forces to one or two departments of the art of building.

Architects as a class are conservative with, and our energies and thought are given to, the designing—to the form of the structure. The carrying out of the work is best left to those equipped for that special purpose. We, of course, must be conversant with the various methods of fabricating the material in order to design the structure properly. As yet our profession rests primarily upon that of form, scale and the disposition of mass and voids (which is the design), more than on the methods or materials of construction.

I may say that all architects are looking forward to the study of this question of concrete treatment with the keenest interest. We have become familiar with the structural side, and are constantly urged to take up the esthetic side of concrete. It holds forth tremendous possibilities, and the day will be a happy one when you have devised methods for the use of cement which will make it possible to do away with wood construction in all city buildings. Can we realize what it would mean to have all our buildings in this city fireproof; the lessening of taxation, to say nothing of the danger of fire?

To tell you the interest which the architects are taking in this subject of concrete and reinforced concrete, I will say that nearly two days out of the four allotted to the annual meeting of the American Institute of Architects were devoted to the discussion of concrete, and we had some pretty stirring times and a good deal of ripping up the back of old methods, and it did us all a lot of good. Still the consensus of opinion at the end seemed to be one of uncertainty and caution; we must be careful. The methods are not yet on the same basis as masonry construction and the manufacture of steel, for instance. It is difficult, if not impossible, to make a test of the work before it is completed, but if it were possible to fabricate concrete under known conditions and under cover, I think the architects would be still more enthusiastic and ready to take the question up on its esthetic side.

The question of weather, the proper mixing of the materials, and the forms and the reinforcement, mean so much that under the very best conditions the contractor has a difficult problem to get his labor to do as he directs.

A report was read at the convention of the Institute by the chairman of the Committee on Applied Arts and Sciences, Mr. Irving K. Pond, of Chicago, the other members of the committee being Messrs. Claude Bragdon, Elmer Grey, Charles S. Klander and Bertram G. Goodhue. This report defines so well the position of the architect in regard to the use of concrete that I have chosen to read it as giving you an authorized idea of the architect's standpoint:

"Although the exact relationship existing between concrete and steel reinforcement under a given condition is yet to be accurately determined,

and the structural use of reinforced concrete is yet to be reduced to an exact science, and although the manipulation of concrete and its application to structural uses have not as yet become an art, yet the fact that in its use and treatment there are immense scientific and esthetic possibilities, brings the subject of reinforced concrete well within the field of study of this committee, especially at this time, when the general topics of steel structure and concrete reinforcement are before the Institute for discussion. It is essential throughout such discussion to keep clearly in mind the true and abiding status of architecture and the architect. The architect is not a mechanical fabricator of mathematical diagrams. His highest concern is with the ideal, and his first sketch should present an idea, an idea which is conceived in beauty. The past has demonstrated that architecture, as the expression of the ideal, can materialize in but one or the other of two great manners: that of the articulated structure, unit added to unit, and that of the plastic mass. The most noble development in the first manner is in the architecture of masonry (brick or stone) and this development has reached its logical limit; in no way, except it may be in mere size, its least noble attribute, is it to be excelled.

"And now comes the ghost of what might have been, and calls for an incarnation, feeling (if a giant can feel) that in reinforced concrete science is preparing a system which can be vivified with the spirit of Art. If this feeling is substantiated, to the architect is opened up a new range of possibilities. The architect becomes in a sense a sculptor, a molder of monumental mass; not the fantastic figure who, at first with sharply insistent blows, and then with infinite persuasive tappings, releases the form imprisoned in the block, but a creative constructor, who builds up his ideal and shapes it by the irresistible though tender molding of mass and form.

"The masonry-clad steel structure of to-day is an architectural anomaly, representing as it does rather a branch of engineering than of architecture; and it is doubtful if any treatment of the encrusting material, be it brick, stone or terracotta, can make the structure architecturally interesting as compared, for instance, with the interest which attaches to a well-designed brick cottage or stable, even. The steel structure, however, will continue to occupy its own domain, but the call of concrete is heard inviting architecture to occupy an as yet undeveloped territory.

"Though the use of concrete goes back into antiquity, plastic architecture would seem to be in the veriest infancy and would seem also to be asking the genius of this age to give it perfect expression and make it worthy to stand with the architecture of the past and yet-to-come. Though the past be examined for precedent, little will be found. Rome used concrete in bulk, but undeniable evidence of a scientific use of the material is wanting. Rome employed masonry in bulk, but again evidence of a scientific use is wanting. Rome applied superficially the arts of other times and countries, but of itself left to posterity only monuments expressive of a highly temperamental force, breathing little or nothing of spirituality. The Spanish missions were built with rare feeling for mass and light and shade; but feeling swayed and science did not guide. With the science of to-day to guide, and the art experience of the past to illumine, into what logical, noble and beautiful forms should not concrete shape itself, to the end of an enduring, spiritualized architecture.

"In this study your committee has taken no cognizance of the concrete block as a structural possibility, believing that such blocks, as well as the terracotta used in the same manner, are mere imitations of stone, and, when used after the manner of stone, are impossible in the architecture of sentiment, and, like all imitations of

one material in another, are inimical to art.

"The possibilities, even the esthetic possibilities, within the range of reinforced concrete construction, can hardly be over-estimated. Little beyond the introductory chapter has been written in the history of reinforced concrete, and every advance in the science of its manufacture and use will signal an advance along the line of artistic application.

"Except in well-defined types, designed to serve certain well-defined uses, it is impracticable to carry masonry construction beyond and behind the façade so as to result in a homogeneous structure, wanting which architecture becomes but a hollow sound. The architecture of a reinforced plastic material may end logically, will express itself throughout the entire structure to the remotest core. The unity, the truth, the harmony of the whole may in every part be manifested. Therefore, again the possibilities inherent in concrete present themselves alluringly to the architect to whom the art means as much as does the science of building.

"The architectural brain is not so congested by the weight of pregnant thought as that at a blow a Minerva shall issue forth full fledged and fully armed. That is not the history of the evolution of an architectural style. It will take time and struggle and developed artistic perception in this, as in former cases, to reveal the possibilities of beautiful and monumental design.

"Yet it is possible that in this as in other ages, commercialism, itself so devoid of esthetic tendencies, will pave the way to the realization of an esthetic idea. A material which holds in itself the qualifications for commercial use will, in that very use, reveal its esthetic possibilities. No material which puts into the hand of the architect power to produce permanent mass and form, and add the enrichment of light and shade, color and texture, will long be ignored when science has made its use commercially possible. It would then seemingly remain only for science to demonstrate the practical value of reinforced concrete in respect to its physical properties, and art must unfold whatever it holds of beauty.

"The steel skeleton developed from commercial necessity, and to clothe and perfect that skeleton, the architect naturally used whatever means lay at his command—stone, brick, terracotta and metalware were called into requisition. To clothe the skeleton in one or another or all of these materials became a fixed habit with the architect, so that when concrete came into use not only was it ignored as a possible clothing for steel, but when the skeleton of reinforced concrete was set up, it was itself clothed after the existing fashion for steel. Such is the fatal force of habit; granting to concrete the qualities ascribed to it, that it is fireproof, that it may be rendered moisture-proof, that once in place it is not affected by atmospheric or climatic conditions, that it can be permanently colored, can be molded and chiseled, that it can be formed in place and need not be applied piecemeal—what better material could be sought for clothing the steel skeleton? And why the need of any cloak at all to such material when it has been treated with any manner of decency or respect by the designer? So esthetically there would seem to be unlimited possibilities in reinforced concrete.

"Although it has not been its purpose to study that especial phase, it seems to your Committee that the esthetic possibilities inherent in terracotta faience as covering materials for the steel skeleton have not as yet been in the highest degree realized, while, as stated before, concrete as a possible covering has been ignored. Simultaneously with their development in the field already assigned to them, it is not inconceivable that ornamental terracotta and tile, beautiful in color and texture, and also sculptured stone, will be called upon to embellish and distinguish, though

not in any manner to clothe or conceal, the concrete structure. The presence of these materials may be needed as a saving grace in these early days of design in concrete, to save the designer from a too brutal conception of the forms they deem the material must necessarily take. There

The Cap Rouge Viaduct.

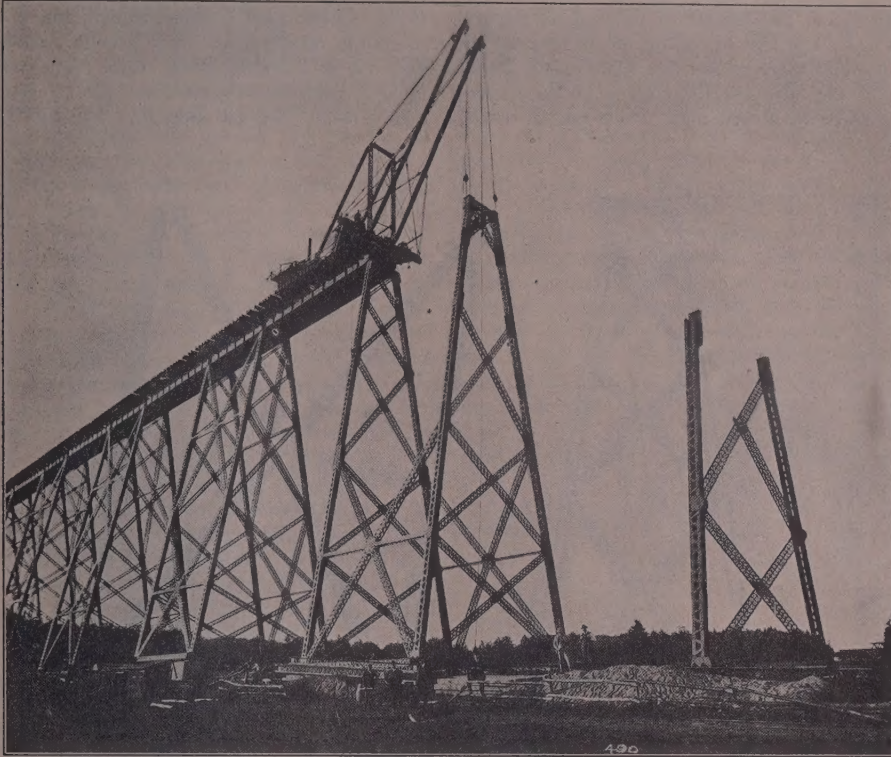
The Cap Rouge Viaduct for the Trans-Continental Railway, Canada, is a single track structure about 3,345 ft. long over all with a maximum height of nearly 173 ft. from low water to base

160-ft., and one 125-ft. riveted truss deck spans.

Several comparative estimates were made considering the longitudinal force specified, and indicated that the maximum rigidity and minimum total cost would be secured by the adoption of comparatively wide towers and moderate length connecting spans, which were finally fixed of the dimensions already stated, but which it was considered by the contractors would have been substantially as economical if the lengths of the towers had been increased 10 ft. more. The standard of 40 ft. was, however, adopted in deference to the general attitude taken by the engineers of proportions of high viaducts and it has proved very satisfactory in construction and operation.

The towers are of special construction and are interesting on account of the make up of the columns and the system of bracing, which avoids all intermediate horizontal transverse struts and eliminates them from the center panels in the longitudinal faces of the towers. This column design has been somewhat modified in subsequent structures proportioned by the same designers to provide better for the transportation and erection stresses and to reduce the wide painting area in the interests of maintenance.

The structure is designed for dead loads of 1,350 lb., 1,500 lb., and 3,000 lb. per linear foot of the 40-ft., 60-ft., and 150-ft. spans respectively, and for the "class heavy" live load and unit stresses conforming to the Dominion government specifications of 1905 which provide for two 180-ton engines 48 ft. long followed by a train load of 4,750 lb. per linear foot. Wind pressure is assumed at 30 lb. per square foot of exposed train and viaduct surface and impact is allowed for by the formula $(l.l.)^2 \div (d.l. + l.l.)$.

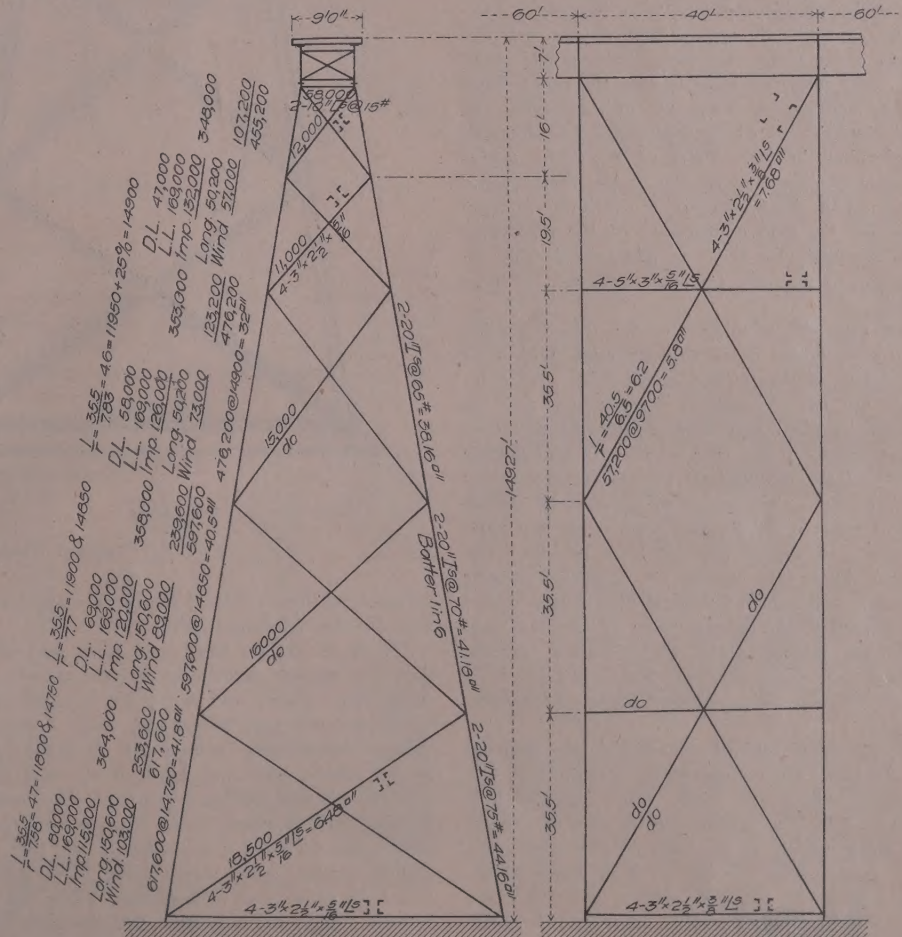


Erection of Cap Rouge Viaduct.

is an unfortunate though marked tendency now in what should be refined and restrained domestic architecture to shape concrete, and its lath and plaster imitations, into the crude, though characteristic forms of the old mission work. It is needless to say that these forms have no meaning outside of their original environment and would not have existed there but for the exigencies of the case, the crude nature of the material procurable and the absence of all skilled labor.

"But to-day, with art and science co-operating, it would seem as though architecture were on the verge of an awakening. Commercial architecture with us is beginning to feel the thrill. Abroad, monumental architecture as well is showing signs of a renewed joy in life, and structural concrete, both of itself and embellished with richer materials, furnishes the new and seemingly adequate medium of architectural expression."

ROAD IMPROVEMENTS continue to attract much attention in Michigan, where a new highway law was passed by the last legislature. During 1907, 53 miles of macadam and 56 miles of gravel roads were built toward the cost of which the State contributed \$1,000 per mile in the case of macadam and \$500 in the case of gravel. An appropriation of \$250,000 was made by the legislature for the two years beginning July 1, 1907, and an additional appropriation for the expenses of the State Highway Department for the same period. The new law concerning roads abolishes the statute labor tax in all townships and provides a cash tax in its place. Under this law, before beginning any permanent improvement on a highway, a survey of the road must be made by a competent surveyor and a profile of the line must be filed with the township clerk, showing all the cuts and fills to be made. Each township becomes a road district under the new law, except in those townships which have more than one surveyed town, and each road district will have a highway commissioner and a deputy who will be known as an overseer.



Typical Strain Sheet of Tall Tower, Cap Rouge Viaduct.

of rail. It contains about 4500 tons of steel and has thirty-one 40-ft. towers and one single bent supporting thirty-three 40-ft. and twenty-nine 60-ft. plate girder spans and one 150-ft., one

All plate girders have a uniform depth of 6 ft. and sustain maximum calculated stresses of 158,800 lb. direct shear plus 115,000 lb. impact increment, equals 273,800 lb. for the 60-ft. span,

requiring a sectional area of 27.38 sq. in. The corresponding moments give a net flange stress of 2,119,000 lb. which, increased by the impact increment, 1,465,000 lb., gives a total of 3,584,000 lb., for which gross cross sections of 44.26 and 40.12 sq. in. are provided in the top and bottom flanges respectively. For the 40-ft. spans, the shear plus increment is 226,800 lb. with a 22.68 sq. in. net web section and the flange stress 1,963,400 lb. with net and gross sections of 21.5 and 23.06 sq. in. respectively to both top and bottom flanges.

The maximum stresses in the tallest bents are given in the accompanying diagram, which also shows the materials used for the members. In bents 110 ft. high to base of rail, the maximum column stress is reduced to 557,300 lb. with a required sectional area of 34.1 sq. in., and the columns are made with 18-in. I-beams weighing 60 lb. for the two lower stories and 55 lb. for the upper stories. The horizontal and diagonal bracing is the same as for the maximum bent.

The height of the viaduct does not fall below 100 ft., except near the ends, at one of which is located the 125-ft. span and the single bent. At the other end there are three towers with their pedestals from 53 to 95 ft. below the base of rail. In all of them the columns are made with 18-in. 55-lb. I-beams. The columns are battered 1:6, which increases the uniform transverse distance 9 ft. apart on centers at the top to from 24 ft. 4 in. to 56 ft. 4 in. at the base.

The column posts are made in lengths of about 32 ft. for the upper stories, which are uniform and vary according to the irregularity of the ground for the lower story. Each section is made with a pair of 18-in. I-beams spaced 15-in. apart on centers with their webs transverse to the axis of the viaduct and their flanges connected by double latticing with flat bars. Successive sections are spliced with double web and flange cover plates, the latter being made about 3 ft. long and extending beyond the inner edges of the columns to serve as jaws receiving the field riveted ends of the horizontal and diagonal longitudinal braces. Pairs of 8 x 3-in. angles about 4 ft. long are riveted to the flange splice plates on the inner sides of the columns to form jaws for the field connections of the transverse X-braces and also serve to add considerable resistance to flexure for the columns at these points.

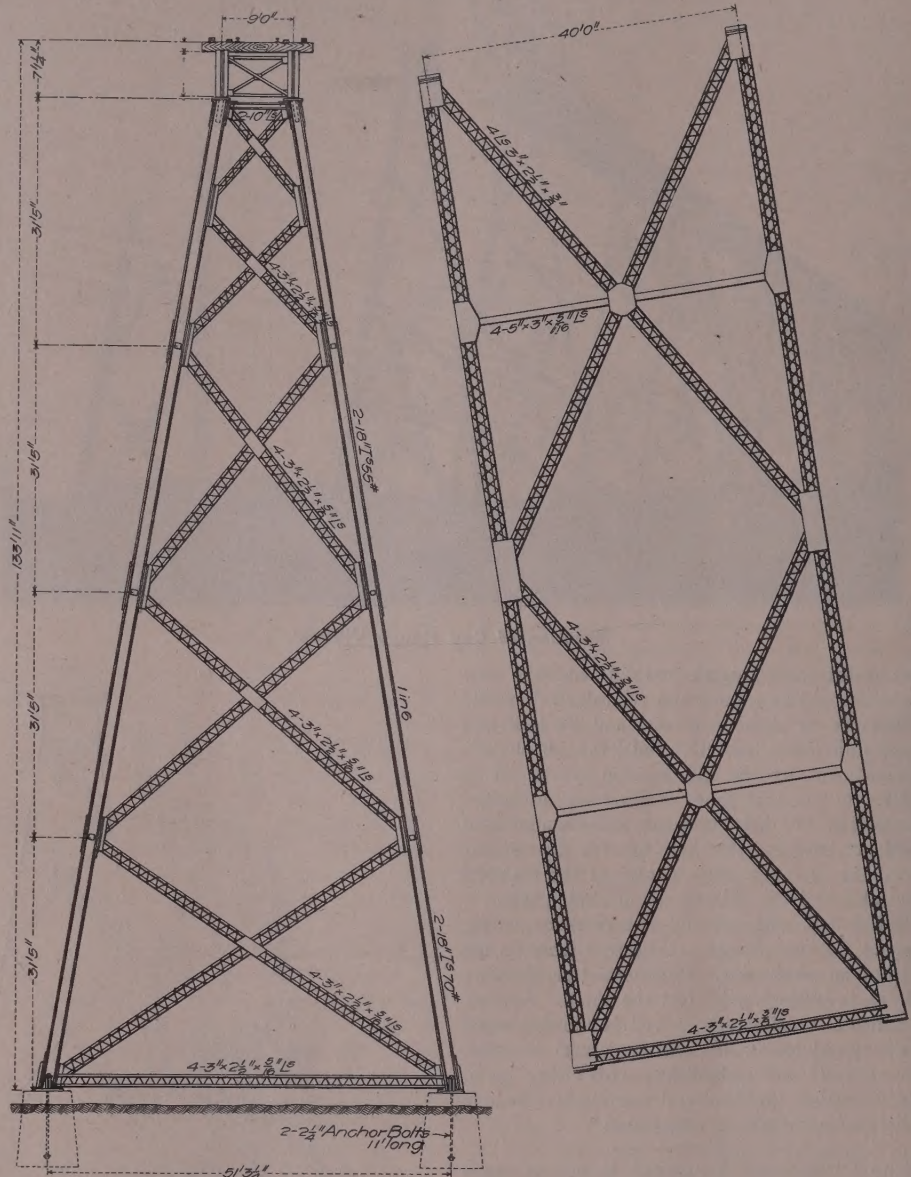
All diagonal members in the tower bracing have rectangular cross sections made with four, 3 x 2½-in. angles latticed on all sides. All diagonals are cut to clear at intersections and are spliced together and with double flange cover plates which, in the case of the top and bottom panels of the longitudinal bracing, connect them also to the continuous horizontal struts which have I-shape cross sections made with two pairs of 5 x 3-in. angles back to back latticed. The column bases are seated on separate concrete pedestals and pairs of vertical distribution angles are riveted to the column webs at the lower end and have bearing plates on top, thus forming pockets and seats for two 2¼-in. anchor bolts 11 ft. long at each column footing of the high towers.

At the upper end of the column, the webs of the I-beams are connected by longitudinal diaphragms which are made with vertical 18-in. I-beams 3 ft. long reinforcing the 36 x ¾ x 38-in. cap plates which, at the ends of the long spans, have guide strips riveted on both edges to engage a cast-iron bed plate with a spherical upper surface finished to a radius of 36 in. A corresponding cast steel bearing plate is finished with a concave surface between which and the convex iron casting there is interposed a sheet lead filler 1/16 in. thick and 21 in. in diameter. The horizontal upper surface of the concave casting is grooved to receive the lower one of a pair of

polished Tobin bronze plates 22 in. square and 5/16 in. thick. The upper plate is countersunk riveted to the 1⅞-in. sole plate on the bottom flange of the girder. The girder is thus free to slide longitudinally on the bronze bearings and to be deflected in any direction on the convex casting without materially disturbing the concentric application and distribution of its load on the column top. The cast fillers are bolted between the longitudinal edges of the shoe plate on the girder and the cap plate on the column and are cored for 1 15/16-in. turned bolts which engage round

have top lateral bracing only. Both spans being provided with the usual transverse vertical sway bracing frames at the ends and at alternate panel points.

The 150-ft. span has trusses 25 ft. deep, proportioned for a maximum top chord stress of 768,700 lb., for which a sectional area of 45.4 sq. in. is required, and is made up with four 6 x 3½ x 9/16-in. angles, two 18 x 7/16-in. web plates and one 2 x 1½-in. cover plate. The truss is divided by vertical posts into six panels, each with a single diagonal member. The 125-ft. span



Typical Tower, Cap Rouge Viaduct.

holes in the fixed ends of the girders and slotted holes in the expansion ends.

The 60-ft. girders have 72 x ¾-in. web plates with top flanges made with a pair of 8 x 8 x ¾-in. upper angles and two 6 x 6 x ¾-in. lower angles riveted over them with their horizontal flanges downwards, making an H-shape cross section which, with one-eighth of the web, gives a gross section of 44.26 sq. in. The bottom flanges have T-shape cross sections, are made with a pair of 8 x 8 x ¾-in. angles and two 17 x 9/16-in. flange cover plates. The 40-ft. girders also have 72 x ¾-in. web plates. Their top and bottom flanges are the same and are each made with two 8 x 8 x 11/16-in. angles. All girders are divided into panels 6 to 7 ft. long by pairs of 5 x 3½ in. intermediate vertical web stiffener angles and 6 x 6 in. end vertical angles. The 60-ft. spans have top and bottom flange X-bracing of single 3½ x 3-in. angles. The 40-ft. spans

corresponds to the 150-ft. span, except that it has only five panels. The maximum chord stress is 522,000 lb., and a sectional area of 37.6 in. is provided by two 15-in., 50-lb. channels and one 18 x ½-in. cover plate. Both spans have top and bottom lateral X-bracing, made, in the end panels, with four angles each. The vertical posts are braced transversely with sway frames composed of 3½ x 3½ and 6 x 3½-in. angles. The trusses are spaced 16 ft. 11 in. apart and the track is carried on 54-in. floor beams and 48-in. stringers.

The viaduct is being erected with an overhead two-boom traveler. All field rivets are driven by pneumatic hammers.

The viaduct was designed and constructed under the direction of Mr. R. F. Uniacke, bridge engineer of the Trans-Continental Railway. The steel was fabricated and erected by the Dominion Bridge Co., Ltd., of Montreal, Mr. Phelps Johnson, manager.

Street Cleaning and Waste Disposal in New York.

Last June, Mayor McClellan of New York appointed Messrs. H. deB. Parsons, Rudolph Hering and S. Whinery a commission to suggest a more effective system of street cleaning and waste disposal than the one then in service. These engineers made an investigation of the local conditions and secured information on the methods followed in other cities. Their report was submitted on Dec. 31 and was made public last week. The general conditions of the city, so far as street cleaning and waste disposal are concerned, are shown in the accompanying table. For the benefit of those not acquainted with all the boroughs of Greater New York it should be pointed out that the conditions vary widely in different parts of the city. Manhattan is almost built up solidly, except for the parks and the extreme northern end, and consequently, in the absence of vacant land, all refuse must be removed from the limits of this borough. The Bronx is partly built up and partly open country, with meadow and marsh lands where waste may be used for filling. In Brooklyn there is a large territory closely built up, but there is yet much open country, with marsh and meadow lands that must be filled before they can be improved. Only a small part of the extensive territory of Queens is built up, and there are large areas of meadows, salt marshes and swamps that must be filled before they can be improved. Richmond is hilly, and only a small part is built up; there are some low lands offering opportunities for filling.

The street cleaning work of the city is intended to cover all the paved streets and some of the macadam roads. Some of the paved streets and many of the macadam roads are cleaned only at considerable intervals of time, and no attempt is made to clean some of the macadam roads except occasionally. Streets under the Department of Parks are not cleaned by the Department of Street Cleaning.

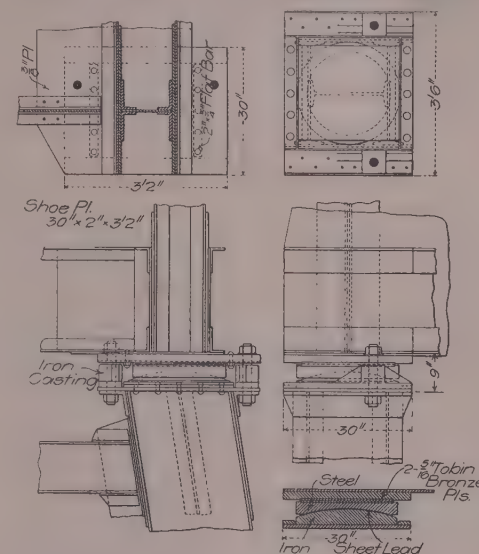
The dirt that accumulates on the streets comes from a variety of sources, some of which are controllable and others are not. The controllable sources of street dirt are refuse swept or thrown upon the streets from buildings, refuse thrown upon the streets by those using them, refuse spilled from passing vehicles, and the detritus from building operations and from repairs of streets and underground works.

In any project for increasing the efficiency and decreasing the cost of street cleaning, the Com-

mission reports, consideration should first be given to possible and practicable means and expedients for preventing the accumulation of dirt upon the streets, thus reducing the quantity to be collected and disposed of by the street cleaning departments. There is evidence that at least 30

per cent. by volume of the dirt now collected from the streets comes from sources that are controllable by the city. City ordinances now prohibit the placing of refuse and litter of all kinds upon the streets, and make it the duty of all police officers to arrest without warrant any person found violating them. The reasonable enforcement of these ordinances would practically suppress street littering and reduce very largely the quantity of street dirt to be collected.

Street dirt is found upon the street in two distinct physical forms; primarily, as coarse and often damp fragments, and, secondarily, as finely pulverized material, either in the form of mud in wet weather or dust in dry weather. In the form of dust it is a serious menace to health and a destructive and discomforting element of city life, the Commission states. The methods of street cleaning in common use remove only the coarser fragments, leaving the most of the mud or dust upon the surface of the street. A number of detailed examinations to determine the quantity of this dust left after a regular sweeping were made. Calling the average volume of



Spherical Bearing for Girders, Cap Rouge Viaduct.

dust collected after the regular sweeping from sheet asphalt pavement 100, the relative quantities collected from other kinds of pavement were found to be 130 from block asphalt, 332 from old wood block and 1,081 from granite block. The Commission states that any method of street

properly cleaned sprinkling would be unnecessary, and the cost of it, now borne by private persons, would not have to be incurred. While macadam, gravel and earth roads must be sprinkled or oiled to effectually prevent dust, the Commission believes that the paved streets of the city can and should be so cleaned that sprinkling will be unnecessary.

Some kinds of pavements can be kept clean with less labor and at smaller cost than others. The Commission estimates the average relative cost of cleaning, equally well, the various kinds of pavement in use in the city under similar conditions of repair as follows: Sheet asphalt pavement, 100; wood block pavement (new), 105; asphalt block pavement, 115; brick pavement, 120; wood block pavement (old), 125; Medina block pavement, 130; granite block pavement, 140; Belgian block pavement, 150; cobblestone pavement, 300. These figures suggest that relative cost of cleaning is an element of no little importance in selecting the kind of pavement.

The cost of keeping pavements properly cleaned is largely affected by their condition of repair. Considering the three conditions of good, fair and bad repair, there is reason to believe that the cost of keeping clean a pavement in fair repair is 20 per cent., and one in bad repair 40 per cent. greater than one in good repair. The Commission is satisfied that the cost of keeping the streets properly cleaned during the past year was at least 20 per cent. more than would be required if they had been in good repair, and that the sum thus saved, amounting to about \$374,000 per year, might better have been spent in repairing pavements.

Of the three methods of street cleaning in common use, hand sweeping is reported to be more effective than machine sweeping, and flushing with water more effective than either hand or machine sweeping. Estimates to determine the relative cost of cleaning under normal conditions indicate, when all items of cost are considered, that the costs compare as follows: Hand sweeping (patrol system), 100; machine sweeping, 113; hose flushing (as usually done), 113; machine flushing, 257.

Flushing with hose is generally done, in this country, with standard fire hose and nozzle, the full hydrant pressure being applied. This is wasteful of water and the force of the jet is unnecessarily great. The Commission believes that the substitution of a smaller hose, a smaller nozzle of special shape, and the restriction of the pressure to not more than 30 lb. at the nozzle, would give equally efficient and nearly as rapid results, while cutting down the quantity of water required about 40 per cent. and decreasing the cost 21 per cent. It is recommended that experiments be made to determine the most efficient and economical hose-flushing apparatus to be used. While machine flushing is no more effective than hose flushing, it is much more expensive and makes hose flushing decidedly preferable.

No method of street cleaning which does not remove the finer part of the street dirt—the dust and the mud—is considered efficacious or satisfactory by the Commission. The only practicable method that will effectually do this is flushing with water, the report states, and provision for flushing must therefore have a prominent place in any plan for satisfactorily cleaning paved city streets. The Commission's conclusion, after careful study, in the light of the best information obtainable both here and abroad, is that flushing, combined with hand sweeping, will prove to be the best and cheapest method of properly cleaning the great majority of the streets of New York.

None of the objections that have been raised to street flushing here or in other cities are believed by the Commission to apply with any weight to the method proposed for New York.

SUMMARY OF INFORMATION RELATING TO STREET CLEANING AND REFUSE DISPOSAL IN NEW YORK.

	Manhattan.	Bronx.	Brooklyn.	Queens.	Richmond.	Total.
Area, sq. miles.....	22.00	40.50	77.50	130.00	57.25	327.25
Population, 1904.....	2,060,041	301,161	1,349,129	199,359	74,969	3,984,659
Population, 1906.....	2,165,015	351,487	1,440,403	222,539	78,943	4,258,387
Garbage, 1906, cu. yd.....	426,784	38,171	190,221	38,811	21,638	715,625
Ashes, 1906, cu. yd.....	2,646,060	229,116	731,534	111,434	36,903	3,755,047
Rubbish, 1906, cu. yd.....	1,646,417	124,248	823,917	94,730	15,666	2,704,978
Street sweepings, 1906, cu. yd.....	703,382	60,904	313,516	70,934	35,262	1,183,998
Garbage, w't per cartload, lb.....	2,037	2,037	2,037	2,037	1,398	.....
Ashes, w't per cartload, lb.....	2,172	2,172	1,950	.....	1,800	.....
Rubbish, w't per cartload, lb.....	1,050	1,050	1,126	.....	300	.....
St. sweep'gs, w't per cart'l'd. lb.....	2,032	2,032	1,538	.....	2,700	.....
Garbage, w't per cu. yd., lb.....	1,110	1,110	1,100	.....	932	.....
Ashes, w't per cu. yd., lb.....	1,086	1,086	975	.....	1,200	.....
Rubbish, w't per cu. yd., lb.....	143	143	154	.....	200	.....
St. sweep'gs, w't per cu. yd., lb.....	1,016	1,016	799	.....	1,800	.....
Granite pavements, sq. yd.....	2,107,525	713,473	2,854,112	389,840	91,282	6,156,232
Specifica on trap pvmnts, sq. yd.....	390,513	22,347	21,648	.....	.....	443,598
Belgian trap pvmnts, sq. yd.....	292,648	.....	774,539	168,784	390	1,236,361
Sheet asphalt pvmnts, sq. yd.....	5,004,330	712,740	5,095,100	287,962	18,133	11,118,265
Block asphalt pvmnts, sq. yd.....	713,189	290,565	240,285	76,632	152,414	1,473,085
Cobble pavements, sq. yd.....	3,305	.....	585,280	.....	.....	888,585
Wood block pvmnts, sq. yd.....	163,258	10,390	37,879	69,403	3,471	284,401
Macadam, sq. yd.....	727,352	1,182,417	1,004,646	2,843,323	2,103,259	7,920,997
Brick pavements, sq. yd.....	18,032	.....	43,676	216,832	52,671	331,211
Iron slag block pvmnts, sq. yd.....	.....	.....	4,001	.....	3,773	7,774
Medina block pvmnt, sq. yd.....	5,088	.....	84,501	.....	.....	89,589
Gravel roads, sq. yd.....	.....	.....	.....	184,377	.....	184,377
Streets and roads, miles.....	433.45	201.59	647.08	365.60	200.12	1,847.84

(a) The estimates for the Brooklyn garbage were taken equal to the measurements made in Manhattan and the Bronx.

mission reports, consideration should first be given to possible and practicable means and expedients for preventing the accumulation of dirt upon the streets, thus reducing the quantity to be collected and disposed of by the street cleaning departments. There is evidence that at least 30

cleaning which does not remove this dust with reasonable effectiveness fails to accomplish the object for which cleaning is designed.

Sprinkling paved streets does not clean them, according to the Commission, but merely converts the dust into mud. If the paved streets were

The most serious obstacle to its immediate introduction in this city is the present inadequate water supply. If the matter is taken up in a spirit of co-operation between the Water and Street Cleaning Departments, there is likely to be found available a large quantity of water for street cleaning during the greater part of many years. One million gallons per day could be counted upon safely, except in times of special scarcity, and during a considerable part of the time a much larger quantity would probably be available. Estimates indicate that to properly flush the streets of Manhattan, The Bronx and Brooklyn would require 8 to 10 million gallons daily. When the proposed additions to the city water supply are available, there will be an ample quantity for a long period to come, and then flushing can be used throughout the whole city. One million gallons per day will be sufficient for the introduction of flushing on a scale large enough to thoroughly demonstrate its merits. The introduction should be gradual even if the supply of water were abundant.

The general features of this system may be briefly outlined as follows:

Hand sweeping would be employed during the day to take up promptly the horse droppings and other coarse dirt, but no systematic or continuous sweeping of the whole surface of the streets would be attempted. Each sweeper, therefore, would be able to take care of a larger area than at present, and the sweepings would be handled and disposed of as now done. Much the larger part of the sweepings would thus be collected, leaving a comparatively small quantity of the fine material to be removed by flushing. The streets would be flushed to remove this fine dirt as frequently as necessary; every day for the streets of heaviest travel; once every week or ten days for the streets of light travel; and at intermediate periods, as may be found necessary, for streets of moderate travel. Heavy traveled streets should be flushed at night; others may be flushed during day or night, as may be found advantageous.

A reliable estimate of the cost of flushing cannot be made in the absence of a complete schedule of the work to be done and other data not now obtainable; but tentative computations for Manhattan and The Bronx indicate that it would be, for these boroughs, somewhere between \$300,000 and \$325,000 per year. The reduction of cost due to curtailing the hand sweeping, to enforcing the laws against littering and to keeping pavements in good repair would undoubtedly offset the additional cost of flushing, so that the total cost under the system recommended would not exceed, and might be much less than, the sum now expended for sweeping.

Since machine sweeping is more expensive and no more efficient than hand sweeping, it should be discontinued and hand sweeping substituted. The machines may be employed as occasion demands for cleaning macadam streets and roads, and they may also be made useful for promptly sweeping up after parades and light falls of snow before it has become packed by travel.

A complete equipment for both hand sweeping and flushing should be provided, so that sweeping alone could be substituted for combined sweeping and flushing, in case of a shortage of the water supply and during freezing weather. When, for any reason, flushing cannot be done, special effort should be made to remove the fine dirt as well as the coarser material.

The Commission recommends that this combined system of hand sweeping and flushing be introduced at once and extended to the whole city as rapidly as it can be developed and as the water supply will permit. In the meantime, it is considered practicable to keep the streets in a much cleaner condition by present methods than they now are without increasing the total cost.

Good supervision and discipline, interest and industry among the employees, more efficient equipment, prohibition of street littering and keeping the pavements in good repair, are the requisites to bring about such a result.

Suitable receptacles should be provided wherever necessary for waste paper and other litter. The laws and ordinances relating to street littering should then be rigidly enforced. This would at once relieve the street sweepers of a very considerable part of the work they have to do. It is the judgment of the Commission that better and more effective cleaning would result from working the sweepers in gangs wherever practicable, and that the actual accomplishment per sweeper ought in this way to be considerably increased.

The Commission recommends that the Commissioner of Street Cleaning be given exclusive jurisdiction over the granting of builders' permits to occupy the streets and the control of all matters relating thereto which affect the operations of the Street Cleaning Department. The city authorities should insist that the specification requirements to promptly clean up the streets after pavement and underground repairs have been made, should be enforced, and not leave this work to be done by the Department of Street Cleaning. The attention of the Department should be given to the subject of providing storage bins beneath the sidewalk surface for the temporary storage of the sweepings.

The average annual snowfall is so great and the city is so large that it is impossible to promptly remove the snow from all the streets. All that can be done is to remove a portion of the total mass of snow, and that portion should be limited to the most important traveled and business streets. All past efforts to do the work of clearing and removal by large numbers of men and carts, hired by the Department, have been most unsatisfactory. The work should be done by contract. A contractor can better handle such men and carts, and the Department would then be able to use its own force for the collection and removal of garbage, ashes and rubbish. In former years the contractor was paid per cubic yard of snow as removed and measured in the carts, and it was found impossible to prevent irregular transactions by any methods of tickets or punching devised. The method of basing payment upon the area cleaned and the depth of snowfall is preferable on account of its simplicity.

The Commission recommends that the garbage of Manhattan, The Bronx and Brooklyn be disposed of by reduction under contract, until further experience with high-temperature incinerators shall have determined the relative advantages and economy of the two methods, inclusive of the cost of collecting all the several classes of refuse; also, that the carcasses of all large dead animals be removed and reduced by contract. It further recommends that the Department of Health investigate the disposal of garbage by private scavengers, as it is questionable whether the meat from animals and the milk from cows fed on city garbage is wholesome for human food.

In the Boroughs of Manhattan, The Bronx and Brooklyn it is recommended that the rubbish be burned, and that the resulting ashes, with the ash and street sweeping collections, be used for making land-fills. In the Boroughs of Queens and Richmond it is recommended that the refuse be incinerated in furnaces carefully designed and constructed for the continued generation of high temperatures.

There are marshes and low lands in all the boroughs which can be filled and converted into property suitable for improvements. Some of these lands are owned by the city. The filling of lands with material containing rubbish, as is being done at Riker's Island and other places, is unsanitary and objectionable, and should be discontinued, the Commission reports. Ashes and street

sweepings alone should be used. The filling of the new bulkhead at Riker's Island should be continued to a limited height and, while this work is in progress, some other land owned by the city should be bulkheaded or prepared for filling. It is suggested that the proper authorities investigate the city's claims to marshes and lands under water, and perfect the city's titles thereto.

The question of final disposition requires the co-operation of all the municipal authorities. The city should plan its work as a whole, and not permit each department or bureau to work independently.

The Commission is of the opinion that the present system of separate collections should be continued. Many of the cart routes are too long, and they should be shortened if possible. The authorities should encourage, as far as possible, the use of metallic receptacles of uniform size for the household ash and garbage collections, that the receptacles be marked with the owner's house address, and that a fine of a fixed amount be imposed for each failure to comply with the collection regulations of the Department.

The distances between pier dumps are in several instances too great for either quick delivery or economy in service. The design of these pier dumps should be improved, and they should be completely enclosed and covered. The piers used for unloading the collection carts should be permanently given over to the Department of Street Cleaning; and the city should reconstruct them to facilitate the work of unloading the carts.

The Commission recommends the plan of having at least one receiving station in each district of each borough. The pier dumps and the proposed incinerating plants can be receiving stations, and the sites can be so chosen as to minimize the hauls.

The Department of Street Cleaning is limited in its jurisdiction to Manhattan, The Bronx and Brooklyn. In Queens and Richmond, the cleaning of the streets is made one of the duties of the Borough Presidents. This arrangement necessitates the multiplication of administration heads and staffs, the duplication of accounts and an increase in the aggregate cost of city scavenging. The Commission believes it would be advisable to have one Department of Street Cleaning for the whole city.

No radical changes in the general organization of the Department are recommended, although the Commission is convinced that in several respects the management of the Department is not as efficient and economical as it should be, and that some changes are imperative if satisfactory results are to be expected. The duties of each employee should be clearly defined by the department, and each superior should be held personally accountable for the work accomplished by his subordinates. Until every employee can be made to realize that the security of his position depends entirely on his industry, efficiency and loyalty, and that personal or political influence cannot shield him, successful organization and discipline will be impossible. As frequent changes of administration tend to disorganize the force and prevent the carrying out of well-conceived policies that require years for their consummation, the Commissioner of Street Cleaning, the report states, should be permanently appointed, subject to removal by the Mayor.

THE WATER SUPPLY of Dawson in the Yukon Territory has to be warmed before it is pumped. The ground is frozen throughout the year, except for the top 2 or 3 ft. during the summer, and consequently the water in the mains would freeze were not some means taken to prevent it. This preventive consists of turning exhaust steam from the pumps and extra steam from the boilers into the supply, which is thereby warmed sufficiently for the purpose.

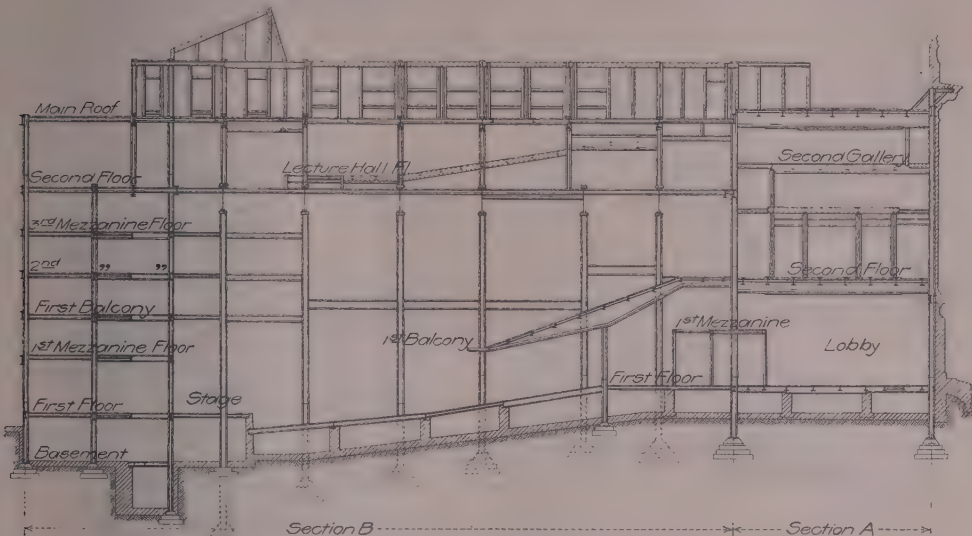
Structural Steel Details of the Brooklyn Academy of Music.

The Brooklyn Academy of Music is a steel cage fireproof structure about 90 ft. in extreme height with a 180-ft front on Lafayette St., which occupies a lot about 200 ft. deep. Although the framework is continuous throughout, the building consists structurally and architecturally of three separate portions designated as sections A, B and C. Section A is two stories or 70 ft.

The rear wall of the stage in section C is 16 in. thick and about 87 ft. high, weighing about 14,000 lb. per lineal foot, and the central portion of it is carried on several plate girders of 58-ft. span with 48-in. webs riveted across flanges of the wall columns. In order to develop lateral stiffness and secure a satisfactory compression member the $6 \times 6 \times \frac{3}{4}$ -in. top flange angles have their horizontal legs reinforced with $6 \times 4 \times \frac{5}{8}$ -in. angles as indicated in the detail, thus considerably increasing the radius of gyration which,

structed pit about 22 ft. deep under any or all parts of the stage.

To facilitate this construction the stage floor is carried by fourteen transverse lines of 9-in. I-beams in three spans of about 17 ft. each, which are supported by two longitudinal rows of intermediate columns and by two special longitudinal girders in the planes of the proscenium arch columns. The intermediate columns are 6-in. I-beams about 22 ft. long with horizontal base plates countersunk riveted to web-connection angles and seated on the carefully leveled concrete floor of the sub-basement. The columns are provided with horizontal shelf angles shop-riveted to their webs to receive the 8-in. I-beams in the mezzanine floor and in the stage floor. They are braced transversely by the I-beams and longitudinally by horizontal rods, called latches, just below the planes of the three tiers of floor beams. These rods act chiefly as ties and are provided with an eye at one end and a hook at the other end, engaging holes in the horizontal flanges of connection angles riveted to the column webs as indicated in the details. This construction, together with the use of bolts instead of rivets in all of the beam and column connections, makes it possible to remove or reassemble any of the elements of the framework with great ease and rapidity. The outer ends of the movable beams in the stage floor are supported by the special longitudinal girders already mentioned, each of which is made with a 15-in. I-beam and a 15-in. channel as indicated in the detail. The I-beams support only the fixed 10-in. transverse I-beams on the sides of the stage and the chan-



Longitudinal Section through Concert Hall.

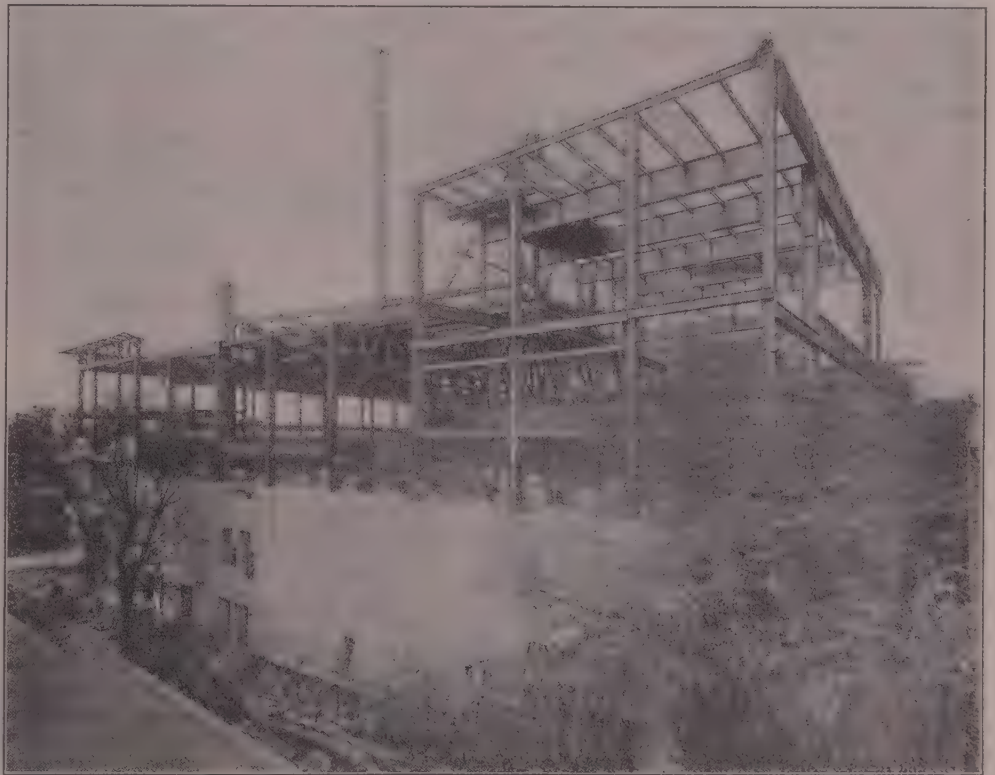
in height above the street level and extends the full length of the Lafayette St. front with a depth of about 44 ft. It has a basement which contains heating and lighting apparatus and the first story just above street level forms a lobby for sections B and C. The second story has a clear height of about 35 ft. and is used for a ball-room with musicians' and visitors' balconies. Sections B and C have their long dimensions at right angles to Lafayette St. and are about 156 ft. long with widths of about 75 and 100 ft., respectively.

Section C has a height of about 70 ft. from the sidewalk to the top of the main roof and contains the main theatre, auditorium, stage, fly and galleries, the dressing rooms being located in section B.

The main auditorium has two balconies and a horizontal ceiling about 60 ft. high. The stage occupies the full width of section C and has a depth of about 50 ft. with a proscenium arch of 58 ft. span. It has a flat roof 83 ft. above the floor and below it is a suspended grid-iron and three fly galleries on each side.

Section B adjacent to section C has a lower story 50 ft. high with one balcony and is used as a concert hall auditorium with four mezzanine floors at the stage end which contain the dressing rooms for the main theatre. The second story, about 27 ft. in height, is used as a lecture room and contains the classrooms of the Burt Institute.

The foundations, carried to a maximum depth of about 30 ft. below the sidewalk, are offset concrete piers proportioned to reduce the maximum load to about 4 tons per square foot on the surface of the dry sand. They have granite tops with cast-iron pedestals, each of them receiving a single rectangular column with the cross-section made with two channels and cover plates. The walls are of brick and terra-cotta and the roofs and floors are all of reinforced concrete flat slab construction. There is no basement or cellar except under the stage, dressing rooms and part of front lobby in the main theatre, and the first floor is carried elsewhere on continuous walls and piers.



Erection of the Brooklyn Academy of Music.

even with this arrangement, has as small a ratio as is desirable with the length of the member.

The central portion of the stage floor, of the full width of the proscenium arch and the full depth of the stage, making a 50 x 50-ft. rectangle, is made with small sections of planks, which, together with the supporting beams, girders and columns, are entirely removable so that any part or the whole of the floor may be quickly removed like a trap or replaced without interfering with any other part of the construction. The mezzanine floor, 13 ft. below the stage floor, is similarly removable, thus providing for an unob-

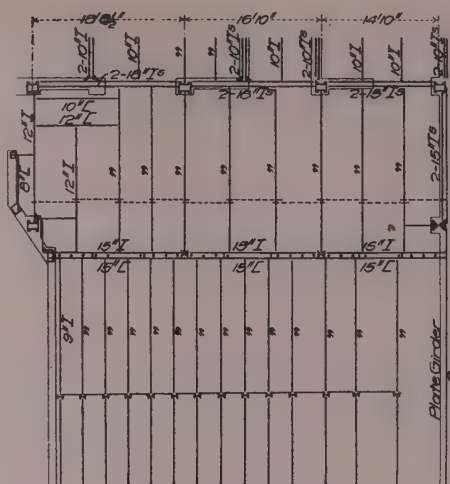
nel supports only the movable 8-in. I-beams in the center of the stage, which take bearing with their lower flanges on a continuous 4×4 -in. horizontal shelf angle riveted to the back of the channel web. The horizontal flange of this angle is punched with pairs of open holes 18 in. apart, through which the beams are bolted with any desired spacing.

In order to resist the heavy external pressure on the outer faces of the side walls in the basement and mezzanine story the brickwork is reinforced at stage floor level by a line of 12-in. I-beams built into it with their webs horizontal

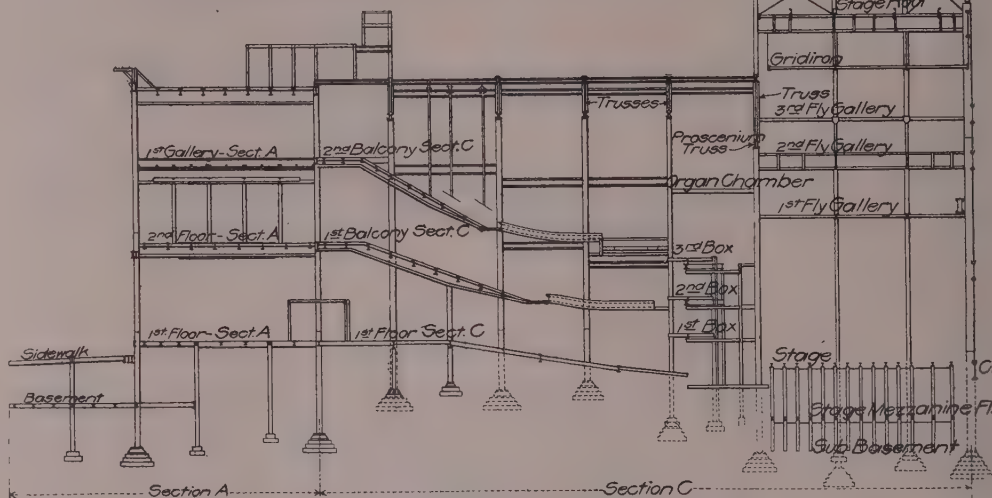
and their inner flanges bearing across the edges of the column faces and web-connected to the column flanges by vertical plates shop-riveted to the column and field-riveted between the abutting ends of the I-beam girders.

The first or auditorium floor has longitudinal beams and transverse girders. Adjacent to the stage the beams are 7, 9 and 10-in. I-beams from about 10 to 19 ft. long and parallel with the side wall. They are supported at both ends on continuous brick walls, that at the stage end being a straight transverse wall and at the opposite end a curved wall concentric with the stage in the center and tangent at the ends. This wall also supports the stage end of the next row of 10-in. longitudinal beams about 10 ft. long which are slightly inclined and are set in radial lines converging to the center of the stage. The outer beams are supported on columns and the intermediate beams are web-connected to 20-in. I-beams about 19 ft. long which form chords of arcs described from the center of the stage. Beyond the third row of inclined radial beams the irregular space from 30 to 42 ft. wide, up to the foyer in section A, has horizontal longitudinal beams parallel with the side walls supported directly by the columns and by straight lines of 18 and 20-in. transverse girders. The top flanges of the beams are coped to the girders and all connections are made with standard vertical web-riveted angles.

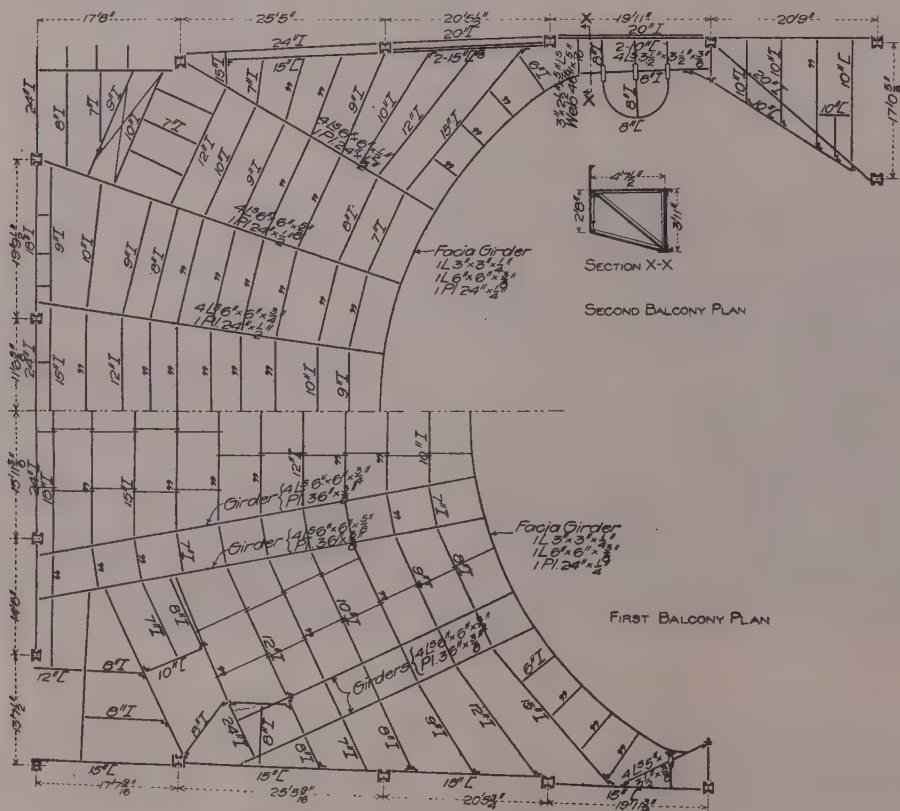
Both balconies are substantially symmetrical about the center line with radial cantilever inclined girders and horizontal transverse beams arranged as indicated in the half-plan diagrams. In the first balcony the girders are fulcrumed near the center point where the inclined bottom flanges are seated on the tops of one-story vertical columns. Both arms of the cantilevers are bent horizontal at the extremities and the shorter arms are anchored to transverse floor girders which take the upward reaction. The stage ends



Part Plan of Stage Floor.



Longitudinal Section through Main Auditorium.



Steel Plans, First and Second Main Balconies.

of the cantilevers are connected by a fascia girder of the usual construction made with a channel-shaped cross-section composed of a 24 x 3/4-in. web plate, one 3 x 3-in. top flange angle and one 6 x 6 x 3/8-in. bottom flange angle. In order to diminish their loads and secure shallower

depths of webs the cantilever girders are arranged in pairs about 6 ft. apart connected by 9-in. I-beams in the lines of the main transverse beams. The maximum girders have a length of 55 1/2 ft. and are proportioned for a maximum load of 180 lb. per square foot.

The boxes are supported by elaborate systems of cantilevers radiating from a single main column and connected to girders which transfer minor portions of the load to auxiliary columns as indicated in the general diagram. The principal cantilever, on the center line, is made with a pair of 15-in. channels about 15 1/2 ft. long riveted together back to back with 1/2-in. connection plates between their webs. This girder passes through the center of the main column and is seated about 4 ft. from the anchor end on a horizontal shelf made with angles connecting the webs of the column channel. The upward reaction is taken through the web-connection plates with a pair of vertical tension angles which

transmit it to the main floor below. The web-connection plates in the cantilever arm project below the lower flanges to receive diagonal I-beams at a lower level that extend to the auxiliary columns and serve as fulcrums for intermediate cantilevers web-connected to them and spliced across them with top and bottom flange cover plates. Their extremities and those of the main cantilever girders are connected by the continuous curved 7-in. fascia channel.

In order to avoid any obstruction in the first balcony the second balcony cantilever girders have their fulcrums suspended by vertical rods from the roof beams. The girders are similar to those in the first balcony except that having maximum lengths of only about 48 ft., their loads are less and they are made singly instead of in pairs. The fulcrum of each is supported by a single vertical rod 3 1/2 in. in diameter and about 30 ft. long with upset screw ends. The upper end passes between a pair of 15-in. channels back to back and its nut engages a 12 x 1-in. bearing plate riveted across their top flanges. The lower nut takes bearing on the milled lower edges of a sleeve made with two bent vertical plates riveted to pairs of vertical angles and flat bars which at their lower ends are themselves field-riveted to the outstanding flanges of pairs of wide web-stiffener angles in the cantilever girders.

The ends of the balcony are extended to the top tier of boxes by horizontal platforms about 20 ft. long and 4 ft. wide adjacent to the side walls. Each of these platforms is carried entirely from the wall columns and from a single intermediate light column about 20 ft. from the end of the balcony and about 5 1/2 ft. from the side wall. About 13 ft. in the clear from the boxes is an organ platform with a 20-in. diagonal I-beam girder 26 1/2 ft. long spanning the corner of the auditorium, connecting columns in the

Water Purification in Ohio.

The Ohio State Board of Health began in 1897 a systematic study of the sanitary conditions of Ohio streams, which was continued for five years. Its purpose was to secure information concerning the availability of these streams as sources of water supply and the nature of their pollution. No public water supply or sewerage may be constructed or extended in the State until the proposed source of supply or sewer outlet has been approved by the Board, and the examination of streams was necessary to furnish the information on which its decisions regarding sources and outlets are based. The purification of water and sewage at numerous places in the State has such a marked influence on the general design of works that the Legislature made a special appropriation for an investigation of the construction, methods of operation and efficiency of such works, this investigation being essentially a continuance of past work of the Board to secure pure drinking water and prevent streams and lakes from unnecessary pollution. The secretary and executive officer, Dr. C. O. Probst, was placed in charge of the investigation, and Mr. R. Winthrop Pratt, chief engineer of the Board, had general supervision of the engineering work. Messrs. Philip Burgess and A. Elliott Kimberly were engaged as special assistant engineers to examine plants for the purification of water and sewage respectively. The following notes concerning water purification in the State are from a preliminary report recently made by Mr. Pratt.

Seventy per cent. of the population in communities in Ohio having public water supplies, depend for their water supply upon surface sources, which cannot be adequately safeguarded from pollution. Water purification is, therefore, a necessity. At the present time there are in use or under construction in this State, water filtration plants at the following places, those marked with an asterisk being under construction: Batavia, *Bellaire, Bucyrus, *Camp Perry, Cincinnati, *Columbus, Conneaut, Dennison and Uhrichsville, Elyria, Fostoria, Gallipolis, Geneva, *Ironton, Linwood Park, Lorain, Marietta, Newark, Oberlin, Pomeroy and Middleport, Rocky River, *Sandusky, Springfield, *Toledo, Upper Sandusky, Vermilion, Warren, Youngstown.

For the reason that the river waters of Ohio and to a certain extent the water of Lake Erie belong to the turbid or clay-bearing class, mechanical filters have, in general, been proved, both by experiment and by actual use, to be most applicable to Ohio conditions. Another reason, of perhaps minor importance, which makes the mechanical system more applicable to the Ohio conditions is the fact that the waters of this State are usually of such chemical composition that they react satisfactorily with coagulants, the use of which is necessary with this process. The mechanical system, therefore, has been adopted at all of the above places with two exceptions, namely, Fostoria and Camp Perry, where slow sand systems have been chosen. In two cases, at Columbus and Oberlin, softening processes have been included in the purification plants. There are, at Shelby and Garrettsville, plants (not listed above) which have been installed simply for the purpose of removing iron from ground water.

The development of the art of designing mechanical filters during the past ten or fifteen years is well shown in Ohio. At the beginning these filters and their accompanying equipment were sold by manufacturers as proprietary devices; but as this system of filtration began to be used by large municipalities and as patents on the process expired, the design was looked at in a broader way and was taken up as a special branch of engineering. At several of the Ohio municipalities careful engineering investigations have

been made before adopting plans for filtration; and in this way the plants have been made to suit local conditions. Some of the smaller places have installed plants without intelligent preliminary study, and without proper detailed plans and specifications, with the result that these plants have proved to be both inefficient and uneconomical.

Detailed examinations have been made of the twenty water filtration plants, including the Oberlin water softening plant, which have been in operation during the period covered by the investigation. Each of these examinations has consisted of from one to five days of continuous observation, and each plant has been visited on an average of four times during the work, the larger plants having been visited more frequently.

During each examination, samples of the raw, coagulated and purified water were taken at frequent intervals. By means of specially devised equipment for making chemical and bacterial field analyses, these samples were always plated and sometimes counted for total numbers of bacteria, at the plant. In addition, determinations for turbidity, color, alkalinity, carbonic acid, and sometimes iron, were made in the field. Samples for the determination of *Bacillus coli* were, during the first part of the investigation, shipped to the laboratory, but later, by using bile media, it was found possible to make this determination in the field.

At the several examinations and inspections those features relating to the construction of the plants were studied and recorded; and complete records were kept of the quantities of water filtered, the rate of treatment, quantity of wash water needed, coagulant used, and all other features of operation which relate to the cost or to the efficiency.

One of the most important features, both from the standpoint of efficiency and economy, studied in connection with the work, has been the quality of alum used; as it was found at the beginning of the tests that very poor grades of this material were frequently purchased by the officials in charge. The question of the relative merits of alum, and copperas and lime, as coagulants, has been taken up in as much detail as possible.

Inefficient Plants.—Of the plants studied there were at the end of the investigation eleven which were producing an effluent which could be classed as safe and eight which were producing an effluent which could not be so classed. Three of the eleven have a but slightly polluted water to treat—that is to say, the work they are called upon to perform is not great. The results might have been different had these plants been treating a badly contaminated water.

The reason for the eight failures were, in most cases, poor construction; although in one case the failure can be attributed to poor operation alone. In the term poor operation are included those plants which are of inadequate construction or are outgrown; that is to say, the principles of construction may have been correct but the plant has been too small to treat the amount of water it was called upon to furnish. Most of the failures are due indirectly to lack of intelligent preliminary study. At several places it has been found that the plant was cheapened during its construction by the introduction of inferior material, so that a satisfactory plant was not actually secured in spite of the excellence of the original plans.

Economical operation of filters has been found impossible in many cases on account of poor design. This has been shown at several plants where the proper use of the coagulant has been prevented by the insufficient size of coagulating basins, where controlling and indicating devices were absent, and where the clear water well was so small that it was necessary to operate the filters at excessive rates during certain hours of

the day in order to supply the demand for water.

The quality, amount and method of handling the coagulant are important features; and it has been found at several plants that the purification effected varied with the amount of coagulant used. A definite minimum amount should be used, even though the raw water be clear. Severe typhoid epidemics have occurred in this State on account of a desire to economize by using too little coagulant.

The necessity for proper training and intelligence of the filter operator has been shown by the investigation to be of utmost importance; and wherever possible every filter plant should have a laboratory, or at least the necessary apparatus for making regular examinations of the raw and filtered water. With the larger plants more complete and more frequent analyses enable poor work on the part of the plant or any portion of it to be readily detected. In case the small size of the plant makes it a distinct burden to have an expert in charge at all times, it is practicable to train an operator of average intelligence to make simple tests by which poor results can be detected, and to have him act under the general supervision of a high-class expert who shall visit the plant at regular intervals, perhaps once a month.

Many of the Ohio plants, including all of the older ones, have been built by filter companies which have furnished a guarantee to insure proper results. These guarantees have not always been as useful as intended, for the reason that they have made the degree of purity of the filtered water depend too much upon the condition of the raw water. In one case there was guaranteed a certain percentage removal of bacteria; and although this guarantee was fulfilled, a safe water was not provided, as the filtered water still contained sewage bacteria. This indicates that the percentage of bacteria removed may not be a measure of the improvement in the water from a disease producing standpoint.

At the beginning of the investigation there were twelve plants which were not producing a safe water. During the investigation, through the work of the State Board of Health, with the co-operation of the local officials, this number was reduced to eight; and in addition, several of these eight were greatly improved. The old Lorain plant, being outgrown, was replaced by a new one.

At the beginning of the investigation some of the operators knew nothing about the principles of filtration in so far as these principles related to efficiency from a sanitary standpoint. No hesitancy was shown in operating the filters at any rate whatever, provided the water could be made to pass through; and little thought was given to other important features. One of the important results of the investigation has been the instructing of filter operators in the principles of filtration. Several of the plants have been improved through the use of a better quality of coagulant, this improvement being due to recommendations made by the State Board of Health. Another reason for improvement has been the fact that the Board has been enabled to study local conditions and to determine in each case the degree to which a given water should be purified in order to be safe.

Essential Features of Design.—Successfully designed filter plants are made up of a number of important parts, each of which has an important bearing on the efficiency of the plant as a whole. Each seemingly unimportant detail has a work to perform, and its failure may cause the plant to become inefficient, even though the remaining parts be working satisfactorily. The following essential features are discussed in the light of the special investigation, with the intention of pointing out their relation to efficient and economical

operation, as well as of indicating those points which are applicable to all cases as compared to those which must be varied to suit local conditions.

In planning a filtration plant, the first thing to be considered is the location of the intake. This has been rarely done in the past for the reason that filter plants have been added to existing water works. By locating an intake in a river above all local pollution, or in a lake beyond the influence of sewer outlets, a better water may be secured, and the filter plant itself will not be called upon to perform unnecessary work. In this way, not only can a purer effluent be produced, but the plant can be operated at less expense.

Although hitherto not generally realized, the choice of a coagulant has an important bearing on the design, and this feature should, therefore, be carefully considered by the designer before drawing plans for a filter plant.

The coagulants which are most commonly used in Ohio at the present time are sulphate of alumina and copperas and lime. With the latter the copperas is, strictly speaking, the coagulant, but the lime must be added in order to insure its precipitation. Alum is used at the majority of the Ohio plants, but several of the largest use copperas and lime.

In choosing a coagulant, the question to be decided is, which will give the best results with the greatest economy? In deciding this question, too much weight has been given to the relative first cost and not enough to the relative efficiency and to the true economy. Preliminary experimental studies with both kinds of coagulants and with the local water are important.

In correctly operated plants which have been built for the use of copperas and lime, there have been obtained as good results, so far as the purity of the filtered water is concerned, as would probably have been obtained with alum. It has been found, however, that the handling of copperas and lime requires an operator of more technical and special experience than does the use of alum, and that when improperly used these chemicals may cause the condition of the plant to so deteriorate that it is impossible for a time to secure good results with any coagulant. Larger amounts of wash water have been found to be necessary with copperas and lime than is the case with alum.

The great importance of efficient coagulating basins is not generally appreciated. With mechanical filter plants, and especially those treating a turbid water, the basins must be depended upon to do a very large proportion of the work. The function of the basins is quite as important as that of the filters themselves. This should be given due weight by the designer.

A coagulating basin which is too small will not permit of securing the greatest benefit from the coagulant. Such a basin may cause the chemical reaction to take place in the filters and thus clog the sand. Furthermore, the investigation has shown that there is a distinct saving in the amount of coagulant necessary if ample time is given, under all conditions, for it to thoroughly react. Efficiency and economy both demand basins of sufficient size. A basin holding two hours' capacity is considered the smallest allowable size from a hygienic standpoint, while a basin of four to six hours' capacity is none too large for economical operation.

Provision should be made for properly controlling the application of the coagulant and securing a thorough mixture with the water before the latter enters the coagulating basins. These should be so designed as to make available their entire capacity; and this may be accomplished through proper placing of inlets and outlets, or, if necessary, by baffling. The level of water in

the coagulating basins should be but little if any above the level of water on the filters, and the channels conveying the coagulated water should be of ample size to prevent the breaking up of the coagulated masses. With some plants provision is made for settling the water previous to the application of the coagulant. This may sometimes be advantageous.

Inadequate filtering area is a very common cause of the failure of plants, and conversely, an ample or apparently excessive capacity, based on usually accepted rates, has been the salvation of many plants at times when the water was especially difficult to treat. A plant can be more safely and economically managed if it is never necessary to overload it.

The number and size of filter units is largely a matter of convenience and economy and may be controlled by local conditions. Enough units should be provided so that one or two can be cut out of service at any time without causing the others to operate at excessive rates, taking into account the available storage for filtered water.

Properly designed and efficient equipment for washing filters is very important. Filters have invariably been found to become foul with inadequate washing, and this prevents proper purification. Unless the strainer and collecting system is of ample size to suit the rate of application of wash water for which it is designed, uneven distribution will result, with the effect of placing all the burden on a portion of the filtering material. Also a needless waste of wash water results from inadequate washing facilities. The wash water troughs and sewer connections which carry away the soiled wash water should be of ample size, and the arrangement of the filter should be such that all parts of the surface can be readily inspected by the operator.

In designing the washing equipment there should be considered the relative advantages, under local conditions, of using air or other agitation, or of depending entirely upon the wash water for cleaning sand. With whichever system is adopted, the design of the piping and washing devices should be made consistent therewith.

The filtered water basin, or clear well, should be of such capacity that it will never be necessary to operate the filters at excessive rates, even when there are unusual drafts upon the water system, such as in case of fire. The clear well should be so constructed and located that its contents can never be contaminated by ground or surface water through leaky concrete walls, floors or roofs. Where possible, it is safer to go to a slight additional expense and locate the clear well away from the pipe gallery and filters, instead of underneath them. Where the amount of available land makes it necessary to place the clear well underneath, every precaution should be taken against leakage through the floor of the pipe gallery. The clear well should always be covered, not only to prevent accidental pollution but also to guard against the growth of objectionable organisms which create tastes and odors in the water. It is, furthermore, desirable to provide baffles so that the filtered water will always be kept in circulation in the well.

Cost of Filtration.—General statements relating to the cost of water filtration must be very broad, for the reason that local conditions, such as size of plant, proper design, use of supplementary unfiltered supplies and relation of output to capacity, control the matters of cost to a great extent. With the larger plants, other things being equal, the cost of filtration per million gallons is less than with the small plants, for the reason that there are certain fixed costs which apply in any case.

As has been suggested in the discussion of

essential features of design, a poorly designed or constructed plant or one of insufficient capacity costs more per million gallons to operate than one which is of proper size for the service required. On the other hand, if the plant is much too large, the interest charges on the excessive construction will increase the unit cost of filtered water.

It will be readily seen that with filter plants, as with manufacturing plants, intelligent operation reduces the cost. By the use of a good quality of coagulant, in correct amounts, and by watching closely the wash water, fuel and labor items, the expenses of operation may be kept at a minimum. In general, the cost of filtration, by the mechanical system, has been found by the investigation to range from \$3.50 to \$7 per million gallons, or from 20 to 40 cents per year per person supplied. These figures include interest charges and represent the extra cost of purifying the water above that necessary for furnishing it unfiltered.

Filtration and Typhoid Fever.—It has been found in Ohio as elsewhere that where a sewage polluted water supply has been the cause of typhoid fever, the installation and proper operation of a well designed filter plant has greatly reduced the death rate from this disease. While records of details are kept by Ohio cities with a fair degree of accuracy, the records of cases are difficult to obtain from the local officials. In order to study the relation between the water supply and the number of cases of typhoid among its users, there have been made during the investigation two detailed studies of the conditions at Youngstown and at Conneaut. All information relative to typhoid was obtained at first hand by the assistant engineer of the Board.

At Youngstown the investigation was made for the reason that the introduction of the water filtration plant did not reduce the typhoid fever death rate as much as was expected. After investigating in detail the history of over 200 cases which had occurred since the installation of the filter plant, it was found that the vast majority of these cases were due directly or indirectly to the presence of old-fashioned privy vaults and polluted wells and to the general unsanitary conditions of living among the poorer classes. The water supply previous to the installation of the filter plant had undoubtedly caused a large number of cases but had been by no means responsible for all of them.

The Conneaut investigation showed conditions quite different from those at Youngstown. At Conneaut a detailed study of all the cases of typhoid which had occurred for a period of three months showed that nearly all these had been infected from the public water supply. The filtration plant at this place, although adequate to purify the lake water sufficiently under some conditions, failed to do so when northeast winds brought additional pollution over the water supply intake. It was during such periods of poor efficiency of the filter plant that most of the cases occurred.

AN ENORMOUS WAREHOUSE, eight stories high and covering 140,000 sq. ft. is being erected in Chicago for Montgomery, Ward & Co., from the plans of Richard E. Schmidt, Garden & Martin. The structure is of reinforced concrete and an adjoining dock will be of the same material. The first floor will have four tracks with room for forty freight cars. The other floors will be divided by fireproof partitions into seven sections of about equal area, and the elevator and stairway shafts will be enclosed by concrete walls. Spiral hooping is used in the columns. The warehouse is being erected by the Geo. A. Fuller Co. and some idea of its enormous extent may be formed from the fact that 100,000 bbl. of Universal Portland cement will be used in its construction.

The Power Plant of a Newark Newspaper.

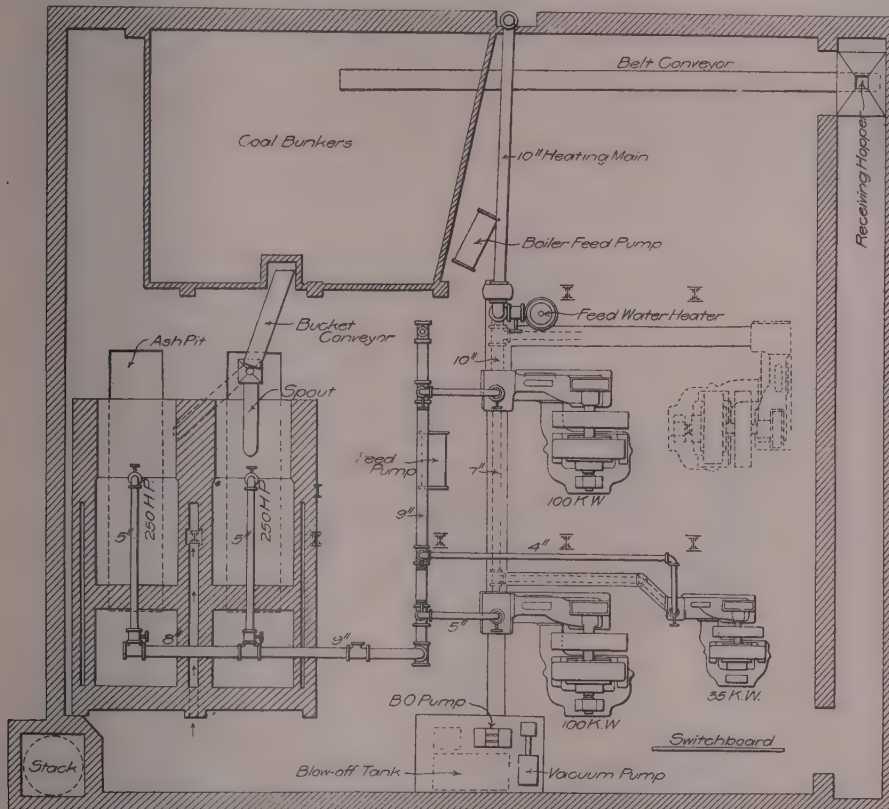
The "New Jersey Freie Zeitung," a German daily newspaper of Newark, N. J., has for a number of years maintained an isolated power plant for running its printing office and lighting its building and the premises of a few neighbors. At first there were two small automatic engines driving a line shaft, to which a dynamo was belted, but in 1904, when additional power was required, this equipment was replaced by a 37½-kw., direct-connected, electric unit, with motor drives for the machinery. As this unit had considerable capacity in excess of the newspaper requirements the sale of current was begun in a small way and subsequently current was supplied to several additional customers, so that in a year the capacity of the generator had been reached.

front building wall. The coal passes from a sidewalk coal hole through a sizing grate on which all large lumps are intercepted and may be broken up, and through this into a receiving hopper directly underneath. Under the hopper there is an inclined belt conveyor which carries the coal into the upper portion of the bunker space near the center to avoid the necessity of trimming. The conveyor is an 18-in. Robins belt conveyor driven by a 2½-h.-p. direct-current motor and is about 40 ft. in total length, having a box enclosure where it passes through the engine room to prevent the escape of dust when in operation. The bunker is a brick enclosure rising from the floor to the ceiling and has a maximum capacity when trimmed of about 130 tons. The coal is delivered to the hoppers of the furnace stokers by an inclined bucket conveyor of the

tween the fronts and the coal bunker of about 10 ft., the furnaces being extended 6 ft. An interesting feature of the setting construction is the enclosure of building columns within the division wall between the two units and in the outer wall of the front boiler. This was considered unobjectionable by the building authorities because there is a large air space surrounding the inside column with openings to the outside of the setting at the rear to allow a free circulation of air around the column. The space surrounding the column is approximately 14 in. square immediately at the column, narrowing to a 9-in. longitudinal space from that point to the rear of the setting where air openings extend through to the open space at the rear of the settings. The outer column, as it merely sets in the outer face of the setting wall with one side exposed to the air, is not thus surrounded with an opening, but provisions are made for making such an enclosure if a third boiler shall be installed in the future with consequent enclosure of this column. The outer wall of this setting would in such case need to be torn down only as far as the space at the rear of the fire brick lining, when the new division wall with the air space could be easily constructed.

As it was the desire to utilize bituminous coal, a Murphy automatic smokeless furnace was applied to each of the settings, by means of which practically smokeless combustion is secured. The stokers are of the usual Murphy construction in extended furnaces, except that they have additional air ducts to ensure the delivery of hot air to the combustion chamber. Coal is delivered to the stokers through hoppers over the feed magazines on either side, under the control of a stoker drive-engine that serves both units and is automatically regulated from the steam pressure for adjustment of the fuel feed to the load requirements. The coal is fed to the inclined grates continuously, while an excess of heated air is supplied through passages opening above the coking space. Ash and clinker are removed by the alternately moving grate bars and a slowly rotating crushed bar at the base of the grate, the latter bar being hollow and having a 3-in. connection with the smoke flue for circulation of air for cooling. Cooling is also effected by the discharge of exhaust steam from the stoker engine against it through numerous jets on either side of the ash discharge opening in the grate. The furnaces are fired with run-of-mine bituminous coal costing \$3.60 per ton delivered at the building. Pits were necessary in the firing floor in front of the furnaces for access to the ash doors for the removal of ashes, which are handled in cans on the sidewalk elevator. The 60-in. brick stack rises but little above the roof of the building, approximately 80 ft. above the basement floor level. In the main flue connection to the stack there is a large damper operated by a Spencer regulator under control of the steam pressure, by means of which a nearly balanced draft is maintained, ensuring a slow movement of the hot gases and comparatively cool flue gas.

The boiler auxiliaries consist of two Worthington duplex steam feed pumps and a pump governor, a Berryman closed feed-water heater and a Knowles vacuum pump for return of condensation from the heating systems and steam traps. The heater is of 300 h.-p. rated capacity and in service heats the feed to temperatures ranging from 183° to 192° Fahr. The vacuum pump delivers the condensation from the heating mains into an 18 x 60-in. cylindrical tank on the wall above it, in which all air and vapor is permitted to separate from the hot returns and escape to the atmosphere; there is a water spray inside this tank by means of which water from the city mains is sprayed into the upper portion to condense any steam that may be given off by the hot returns. The vapor connection from the blow-



Plan of the New Power Plant of the New Jersey "Freie Zeitung."

At this time, an attempt was made to supplement the steam plant by a suction producer plant which, however, eventually proved unsatisfactory, and finally an entirely new steam plant was designed for the operation of a power building the newspaper's owners were erecting, which should also supply power to the printing plant and the outside customers in addition.

The new building is a five-story brick and steel frame structure opposite the printing plant. The structure is about 60 ft. square and has 12-ft. stories with the exception of the basement in which the power plant is located, which has a clear head-room of 22 ft. to afford ample room for steam piping, the floor level being depressed 16 ft. below sidewalk level. The basement is without a partition between the boilers and the generating equipment, a 20 x 22-ft. space only being partitioned off on one side for a coal bunker, there being insufficient space in the area under the sidewalk for the amount of fuel that it was desired to keep in storage. A platform elevator rises within the basement wall to street doors at the sidewalk level; this elevator is utilized for handling ashes in cans to the sidewalk and for delivery of machinery to the basement.

Coal cannot be delivered direct to the bunker, as the latter is about 30 ft. to the rear of the

grain elevator type which rises from the lower front side of the bunker enclosure to a swinging spout over the furnaces from which the fuel may be fed to any hopper. The spout is pivoted over the front furnace so as to serve not only the present boilers, but also a future unit for which space has been provided.

As the maximum load carried by the plant, including both power supply and heating, rarely goes much above 200 h.-p., two boilers of 250 h.-p. rating each were selected, one for reserve, and space was provided for a third in case of future growth of the commercial load carried for outside customers. Owing to the location and character of the building, it was the desire to use water-tube boilers and the inclined-tube forged-header type built by the Edge Moor Iron Co., Edge Moor, Del., was selected. They are the one-drum vertical-pass type, each containing 144 4-in. tubes, 16 ft. in length, and are designed for a working pressure of 135 lb. The inclined tubes are expanded into headers of the water leg type of forged and stayed steel plates, which are carried up and form the end enclosures of the two longitudinal steam drums, to which they are attached by special staying. They are mounted in a double setting in the rear corner of the basement, so arranged as to leave a space at the rear of 6 ft. and a firing floor space be-

off tank is also connected into this separating tank for the like purpose. The blow-off tank is a 3 x 6-ft. cylindrical steel tank in a sump pit underneath the floor at one side and receives the blow-off discharge from the boiler through a 3-in. connection as well as also all drainage from the basement floor. As this tank is below the level of the sewer in the adjoining streets, the discharge is raised to the latter by a $4\frac{1}{2}$ x $2\frac{3}{4}$ x 4-in. duplex sump pump with float control from the tank, the float rod projecting up through the floor and connecting with the lever of a throttle gate valve supplying the pump.

The steam piping of the plant is extremely simple. The high pressure system has a 9-in. header with 5-in. double-valved branches to the boiler nozzles and a 4-in. and two 5-in. branches to the engines, with blank outlets for a future boiler and engine. The 10-in. exhaust main is arranged in a trench under the basement floor and has 4-in. and 6-in. connections from the engines. Near the middle of the room there is an inductive connection made from this main to the feed-water heater and thence it rises through a Cochrane grease extractor to the heat distributing connection that is carried up into the power building and into the adjoining buildings on both sides. Atmospheric relief is provided by a Kieley back-pressure valve connected into the latter riser near the roof, which connects to a Swartout exhaust head above the roof.

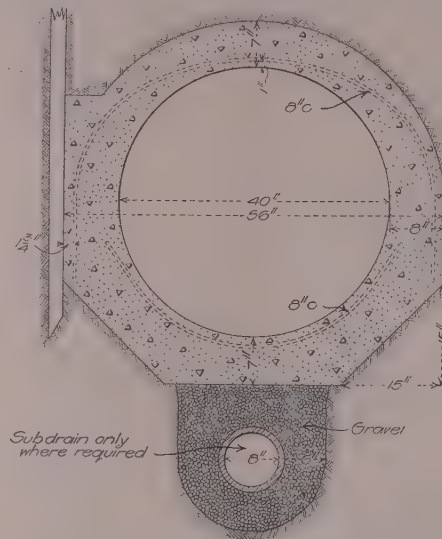
The power equipment consists of one of the direct-connected generating units used in the original plant in the basement of the newspaper building, and two larger units, all Westinghouse multipolar engine type machines direct-connected to Fleming single-valve simple engines built by the Harrisburg Foundry & Machine Co. The smaller unit has a rating of $37\frac{1}{2}$ kw., while the two larger new units are each of 100 kw. capacity. The latter have $14\frac{1}{2}$ x 14-in. cylinders and operate at 250 r. p. m., while the smaller unit has a 10 x 12-in. cylinder and operates at 300 r. p. m., this engine having been originally designed to operate at a pressure of 80 lb., at the old plant. Engines of the simple expansion type were preferred for this plant, as throughout the heating season practically all of their exhaust is utilized in the heating systems, so that compounding would have been of little or no advantage. Swartout separators are used on all engines.

As the range of distribution is not large, not exceeding 2,000 ft. in any direction, the 125-volt tension of the original plant in the newspaper building is retained for the new equipment and the generators are compound wound for voltage regulation under loads. The generator and distribution circuits are controlled on a six-panel standard Walker switchboard.

Electric current is now furnished for lighting and operation of machinery at the newspaper plant, to ten tenants of the power building and eighty outside customers, for the greater part stores and business houses in the blocks adjoining the newspaper plant. The average day load is in the vicinity of 600 amperes, while in the early evening it averages 1,100 amperes, going as high as 1,400 amperes on certain occasions. This load is ordinarily carried with ease with one of the large units and the small unit. The ultimate capacity of the two larger units was at one time tested on the occasion of a carnival in which extra lighting was done by all of the power consumers, when the load rose to nearly 1,800 amperes, but it was easily carried by the two larger units. It will be evident from this that the three units at present installed provide ample reserve capacity, whereas there is sufficient space reserved in the basement to permit of the addition of another boiler and a 150-kw. generating unit, which will in all probability soon be demanded by the increasing number of power customers. A considerable portion of the connect load on

the plant is in motors, 22 h.-p. being connected for the operation of the printing plant, while motors to a total capacity of 112 h.-p. are operated in the power building and about 40 h.-p. by outside customers.

The heating service operated from the plant is similarly quite extensive, embracing the supply of steam to the newspaper and printing building, to the power building, and to the buildings adjoining the latter on either side. Exhaust steam from the steam-using equipment serves as the basis of the heating supply, the 10-in. exhaust main from the plant delivering through the Cochrane oil extractor to the heat distribution system. Make-up steam is added to the heating system through a pressure-reducing valve when the exhaust supply is insufficient for the heating requirements. Steam circulation in the heating mains and radiation is rendered positive by operation with a system of vacuum returns. The heating piping is all laid out on the two-pipe



Forty-Inch Sewer, Salt Lake City.

system, the returns being connected in the basement to a return gathering main that connects with the Knowles vacuum pump, which, as above stated, returns the condensation to the feed pumps. The total amount of radiation supplied from the plant is 5,800 sq. ft., of which 1,100 sq. ft. is located in the newspaper building, 2,000 sq. ft. in power building, 2,700 sq. ft. in the adjoining buildings.

Mr. E. S. Prieth, manager of the "Freie Zeitung," has been responsible for the development of the power service in connection with the operation of the paper. The power and heating plant was installed under the direction of Mr. Clifford D. Meeker, consulting engineer, New York, who was at that time with McKenzie, Quarrier & Ferguson, New York. The latter firm, who are New York representatives of the Harrisburg Foundry & Machine Works, were consulting and contracting engineers for the plant.

CIVIL ENGINEERING PROSPECTS in the United States were briefly summarized by Dr. J. A. L. Waddell in a recent talk to the pupils of the Prosser Preparatory School, at Kansas City. It is absurd, he said, to expect construction work to increase in the same ratio as the number of graduates from technical schools. Hence, he looks forward to a time, probably soon reached, when the supply of young engineers will exceed the demand. Such a condition should not deter any youth from taking an engineering course, however, because there are many branches of business in which a knowledge of engineering is useful and such training is desirable on the general grounds of education for the proper discharge of the duties of citizenship.

An Intercepting Sewer in Salt Lake City, Utah.

An intercepting sewer is being built to provide an outlet for the sewers in the low-lying sections of Salt Lake City. The sewerage system of that city is arranged to carry the domestic flow only, the storm water passing to the natural water-courses in the street gutters. The major part of the city lies on a long slope at the base of the foot-hills of a high range of mountains. This slope is quite steep on the rear of the city, but gradually flattens out so the business district is on comparatively level ground. Below the business district is a considerable area adjacent to the Jordan River, which is lower than the banks of the latter and too low to be served by a main outfall sewer through which the sewage of the remainder of the city is carried. The river has a flat grade and normally carries only a small flow, its mouth being in the Great Salt Lake. The main outfall sewer of the city extends from the southeast to the northwest, generally parallel to the river along the lowest contour at which a gravity flow can be obtained safely. This outfall has a total length of 7.8 miles, leading to a broad irrigation farm some $3\frac{1}{2}$ miles north of the city. A series of settling basins are also operated in connection with this farm, under certain rainfall conditions, and the effluent from these tanks discharged into the river near the Great Salt Lake.

The existing topographic conditions, together with the necessity for serving the low district without discharging the sewage into the river, required the construction of a main intercepting sewer extending the length of that district. This sewer has a total length of 3.9 miles, and varies from a minimum of 15 in. in diameter at the upper end to 40 in. at the lower end, where it terminates in a low-lift pumping station. The pumps in this station discharge into a 24-in. force main, 4,600 ft. long, which leads to the main gravity outfall sewer.

In sizes up to and including 18 in. in diameter the intercepting sewer is of vitrified pipe. Above that size it is of reinforced concrete, with a circular section having the sides of the base cut away on a 45 deg. angle in good soil. The details of the standard 40-in. section are shown in an accompanying illustration. Twisted steel bars placed as shown were used for reinforcement, the bars in the arch and invert being spaced 8 in. apart on centers. The concrete is made of Utah Portland cement, sand and pit gravel, the usual proportions, 1 cement, $2\frac{1}{2}$ sand and 4 gravel, being varied as required to produce the densest mixture.

The excavation and backfilling of the sewer trench were handled by a Potter trenching machine. Owing to the nature of the soil encountered practically all of the trench, which reaches a maximum depth of 18 ft., and has an average depth of about 12 ft., had to be sheeted. The lagging used for the sheeting consisted of 2 x 12-in. plank with 3 x 12-in. plank for rangers and Dunn extension jacks on the cross braces. Since much of the trench was also below the ground-water level, pumps have to be used almost continuously to lower that level sufficiently to permit the concrete work to be handled properly. Under the worst conditions, an 8-in. sub-drain was also laid 6 in. below the invert of the sewer and surrounded with 6 in. of gravel in order to carry the ground water away until the sewer barrel could be finished.

The concrete was made in a Smith portable mixer at one side of the street, and was wheeled to the top of the trench from which it was dumped into place. Blaw collapsible steel forms were used throughout the work to peculiar advantage under the difficult conditions encountered. About 100 ft. of these forms were available. The trenching machine enabled excavation and backfilling to be in progress on 200 ft. of

trench, so that from 250 to 370 ft. of trench was kept open. The concrete was carried ahead as rapidly as possible and was allowed to set 2 days before backfilling was commenced. The forms were not removed until at least 2 days after the concrete had been placed, when they could easily be taken down and moved ahead.

The pumping station to which the intercepting sewer delivers was approaching completion in January when these notes were prepared. It has a concrete pump pit, 30 x 30 ft. in plan and with its floor 20.5 ft. below the level of the street in which this pit is located. The pit is separated into four practically equal compartments by transverse and longitudinal division walls. The

in an unusual manner, owing to the porous, sandy character of the soil in which it was built, and to the large amount of ground water encountered. As the excavation was about 30 x 30 ft. in plan and 25 ft. deep it could scarcely have been sheeted at any reasonable cost, nor without more or less hazard. The four side walls were therefore started on the surface and built up to a height of 6 ft., the bottom of each of these walls being shod with a reinforced-concrete pointed shoe to act as a cutting edge. The excavation was then started in the space enclosed by the walls and was carried down uniformly in such a way as to cause the portion of the walls already built to sink evenly. An open caisson

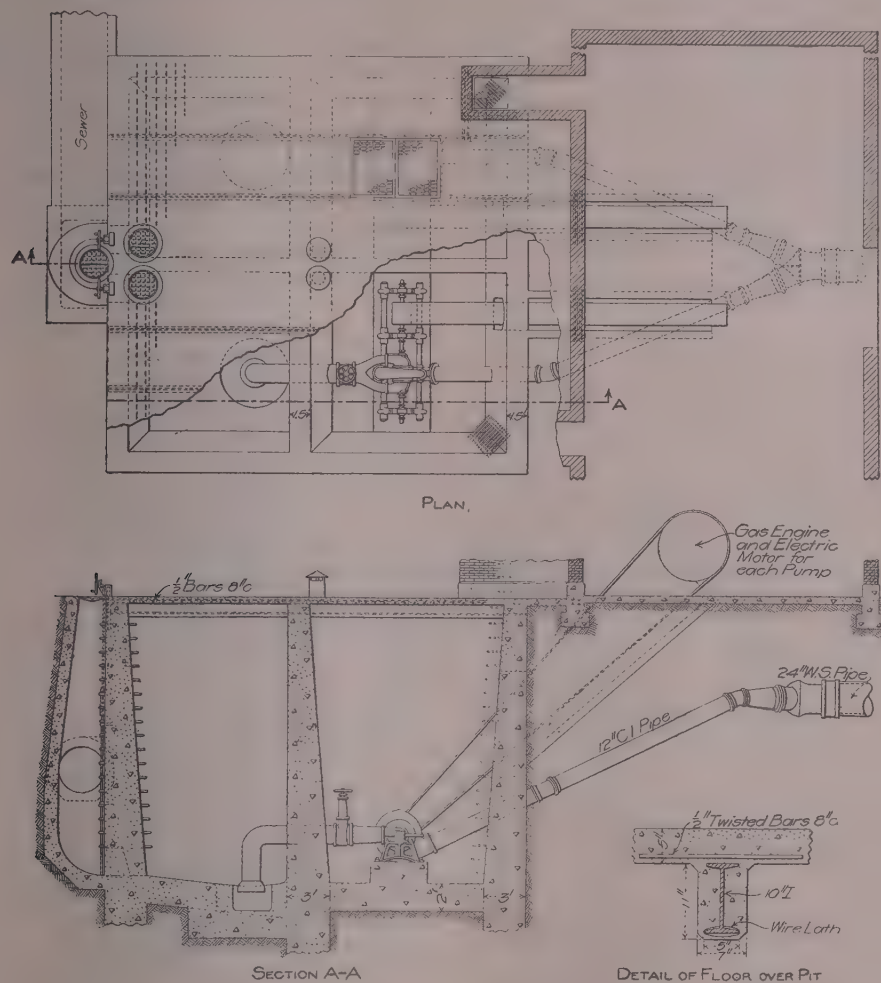
Developments in the Paper and Pulp Industry.

The American paper and pulp industry has reached such an important place among national manufacturing interests, that the mill architect and engineer is obliged to keep in touch with the developments taking place in it, unless he is willing to neglect a portion of his field in which important changes are considered imminent. What these recent changes have been, which foreshadow those to come, is well shown in a paper read before American Paper and Pulp Association recently by its chemist, Mr. Arthur D. Little, of Boston. The more important features of this review are given in this article. The most significant development of the year has been the serious and general inquiry all over the world for new sources of paper stock. Wood is undoubtedly destined to maintain a position as one of the chief sources of supply for an indefinite number of years, and no possible substitute for ground wood is even in sight. There are nevertheless plenty of signs, for those who will read them, Mr. Little says, that we are on the eve of a readjustment in paper-making methods. For a considerable number of years the makers of many sorts of paper have found themselves in a position where it was wood fiber or nothing else as their raw material. This general use of wood fiber as the only available basis for many branches of the industry has made for a greatly increased production, but it has not always made for improvement in the quality of product. To the growing scarcity of pulp wood, the continually rising price and longer haul with which paper makers using this material are now contending, will in a few years be added the competition of new and better stock which even now can be produced more cheaply than any bleached wood fiber.

The time is rapidly approaching when we shall see upon the market many new paper stocks as bleached and unbleached pulp and half-stuffs, and these will be as readily available for immediate use as bleached sulphate is to-day. This means of course a gradual displacement of wood fiber from its present position of supremacy. It means also a far wider range in the quality and characteristics of available raw materials, as a result of which variety will come a broader scope for the exercise of a critical judgment and a greater skill on the part of the paper maker in the selection and manipulation of his materials. This condition is bound to react to the advantage of the industry generally, and especially to the advantage of the smaller mills in the hands of expert and progressive manufacturers. There should follow a decided rise in the standard of quality, particularly in bag and wrapping papers, and in those papers which may be expected to replace the cheaper grades of book, wood writing and envelope, as now manufactured. At the same time the range of possible production in many mills will be extended.

The most important material available in our own country and now wasted is undoubtedly the waste flax straw of our Northwest. The total area grown to flax for seed runs as high in some years as 3,700,000 acres. A ton and a half of straw to the acre is said to be a moderate yield, upon which basis we have over 5,000,000 tons of straw a year. This straw contains more than 20 per cent of linen fiber, so that, disregarding the inconsiderable amount of the fiber which is worked into tow, binder twine, and a few other similar coarse uses, there is here available more than 1,000,000 tons a year of the finest paper stock, equally suitable for the highest grades of paper as well as for bag and wrapping papers of a quality not now approached.

Within the last year at least three machines have been perfected for separating the short



Suction Wells and Pump Pits, Salt Lake City Sewer.

pair of compartments on each side of the transverse wall form a suction well and a pump pit for one of the two pumping units to be installed. The intercepting sewer terminates in a drop manhole, 20 ft. deep, built against the rear side of the suction wells. Two 2-ft. circular openings at the bottom of the rear wall of those wells connect each of the latter with this manhole. Each of these openings is controlled by a sluice gate operated by a hand wheel on a stem extending to the surface.

Each of the two pump pits is arranged to contain a double-suction 12-in. Byron Jackson centrifugal pump with a capacity of 4,500 gal. a minute. The suction pipe of each of these pumps has its lower end in a sump dropped 1.75 ft. below the bottom of the suction well in the rear of the pump pit. Each pump is arranged to be belt-driven by either a 150-h.p. gas engine or an electric motor. The engines and motors are in a 20 x 46-ft. brick station building at the surface. The pump discharges against a static head of 35 ft. into a 12-in. riser pipe, which connects with a 24-in. wood-stave pipe main, 4,600 ft. long, that discharges into the main outfall sewer.

The construction of the pump pit was handled

was thus formed in which the excavation was handled without any particularly unusual difficulties. When the excavation had been carried down far enough so the top of the portion of the walls that had been built was nearly at the ground level, the walls were carried up 7 ft. higher and then the excavation was started again. In this manner the excavation was thus carried to a depth of nearly 25 ft. below the surface, and 20 ft. below the ground-water level, the latter being kept down meanwhile by pumps. The concrete bottom was then laid, sealing the caisson so it could be pumped dry, and the two interior division walls built.

The intercepting sewer and pumping station were designed and built under the direction of Mr. Lewis C. Kelsey, city engineer of Salt Lake City. Mr. L. H. Krebs is assistant engineer in charge of the sewerage system of the city. The intercepting sewer and pumping station were built by James Kennedy, of Fargo, North Dakota.

MINUTELY DETAILED REGULATIONS for the design and execution of concrete and reinforced concrete structures have recently been adopted by the Austrian Government.

fiber which adheres to our southern cotton seed after the cotton has been ginned. An average cotton crop may be counted on to yield at least 600,000 tons of this short fiber which now goes into cattle feed, to the detriment of the latter. One meets occasionally with paper makers who have tried the fiber but who almost invariably condemn it as unworthy of serious consideration. Within the last few weeks a writer in an English journal stated with much positiveness that this cotton hull fiber was "only suitable for browns and wrappings." The real fact is that this fiber is easily reduced to a pure white stock wholly free from any sign of hull, and a failure to secure as good results from this neglected fiber as from a good grade of cotton rags is a reflection upon the skill of the man who tries to handle it rather than upon the quality of the fiber itself.

On the average 22,750,000 tons of cotton stalks are each year burned or plowed under, or otherwise wasted. These stalks have a woody structure which lends itself readily to treatment by the sulphite process, yielding a fair proportion of fiber well suited for the production of paper of the lower grades. It is of course not feasible to attempt the removal of the bark, but this is so broken up and distributed through the sheet as to be unobjectionable in papers for a wide variety of use. There are, however, undoubted difficulties in the way of the preliminary handling, transport and storage of the material by reason of its bulk. Somewhat the same difficulties are encountered in any large-scale attempt to utilize the first-class fiber which in almost unlimited amount has been shown to exist in the outer shell of the cornstalk.

The exceptionally high tides which occur in the Gulf of California during the full moon of May each year, acting together with the melting snows from the mountains, cause the Colorado River to overflow its banks along its lower reaches, which are thus built up of rich alluvial soil. The climate is almost tropical, the temperature often reaching 135° in the sun. Great stretches of this country are covered with wild hemp, which grows luxuriantly under these favoring conditions. Many tracts are over 100,000 acres in extent. No data are available as to the yield of fiber, but hemp is known to grow to a height of 15 ft. in eighty days, and to yield 1,500 to 2,000 lb. of actual fiber per acre. This fiber is of the very highest grade for any of the purposes of paper making.

Flax is pre-eminently a crop for new lands, and is often the first crop sowed after such lands are turned over. Great crops of flax for seed are therefore naturally raised in Canada, particularly in Manitoba and the Canadian Northwest. Up to this time little or nothing has been done in the way of utilizing the fiber, although the Canadian flax should prove more valuable than our own by reason of the greater care taken in harvesting, the flax being cut or pulled and kept straight in sheaves while the seed is being separated.

The so-called marsh hay, which is said to closely resemble esparto in structure and the paper-making quality of its fiber, grows wild in great abundance over large areas in Canada, while the American wild rice, *Zizana aquatica*, also grows in such profusion that 100,000 tons a year are available on the shores of the Canadian lakes alone. Paper-making tests made in England rank this fiber also with esparto.

Especially noteworthy in the developments of the year is the serious and general revival of interest in bamboo as a source of paper stock. Its superlative value for this purpose was urged by Routledge in 1875 after his introduction of esparto into England. Very favorable conclusions as to bamboo were reached by R. W. Sindall in his report to the British government on available sources of supply of paper stock in the

British Colonies. These conclusions are now amply confirmed by Raitt, who has recently published the results of numerous experiments of his own on the mill scale in Burmah, Bengal, Malabar, and Straits Settlements, and by Richmond in the laboratory of the Bureau of Science at Manila. Raitt finds in bamboo a really inexhaustible raw material. He recommends the establishment of bamboo plantations so arranged that one-third of the whole plantation shall be cut over every year. This will secure absolute permanence of growth, and in fact such systematic cropping will increase production. Raitt finds the yields of bamboo to be 11 tons per acre where the growth was poor, 18 tons with moderate growth, and 44 tons per acre with luxuriant growth. The best yields 44 per cent of fiber and the best results in treatment were secured with three-year old shoots. The internodal pieces alone were digested, the rejected nodes amounting to 8 per cent of the total weight. The stems were cooked at 60 lb. pressure for 10 hours with 30 lb. of 76 per cent caustic per hundredweight of dry bamboo. The fiber bleached to good color with 20 lb. of bleach per hundredweight.

Raitt further finds that the stems were easily reduced by the sulphite process, giving a yield of 51 per cent, and bleaching to a brilliant white with 16 lb. to the hundredweight. He estimates that in a 200-ton sulphite plant at Rangoon the cost of bamboo fiber will be \$24.30 a ton.

Richmond, whose excellent work in the Philippines deserves the highest credit, finds that it is quite unnecessary to remove the nodes prior to cooking provided the stems are first passed through crushing rolls and afterwards, for convenience of packing in the digester, cut to 3 or 4-in. lengths. He obtains from the different varieties of bamboo yields of 40 to 43 per cent of bleached fiber by the soda process. The sulphite process gives 43 per cent bleached fiber, which puts bamboo on about the same basis as wood in this regard. The unbleached sulphite was nearly as white as the thoroughly bleached pulp.

The importance of these figures becomes evident when we consider that we have in bamboo a raw material directly comparable to wood in many respects, but with no bark to remove, and much more easily reduced to pulp by either the sulphite or soda process. Bamboo requires a weaker liquor and much less of it, and is reduced in less time with far less fuel consumption. A properly situated mill is assured of a regular supply with a yield per acre every third year greater than that resulting from the cutting over of well-grown spruce lands of good stand. Bamboo in fact has been known to grow 2 ft. in three days in the Philippines. It is interesting to calculate from Raitt's figures for moderate growth that only about 16 square miles is required to maintain indefinitely the supply of bamboo for a 100-ton mill.

Two other raw materials for paper stock among those studied by Richmond demand special mention. These are Cogon Grass and Abacá or manila waste. Cogon Grass grows from 2 to 4 ft. high in even stands on open lands, foothills and mountains in the Philippines. In content of cellulose as well as in general composition, Cogon closely resembles esparto and yields with equal ease to treatment. It gives a very fine, clean paper, stronger and with more snap than esparto. It does not, however, bulk as well, but for many uses should prove even more valuable.

The hand cleaning of manila fiber involves the production of much waste, while all of the several fiber-stripping machines now on trial in the Philippines produce waste in much larger proportion. For every ton of merchantable manila fiber produced in the Philippines, more than a ton of fibrous waste is made in the process of hand stripping, while nearly four times as much waste is now lost by the methods of ma-

chine stripping. This Abacá waste constitutes one of the most intrinsically valuable raw materials anywhere available for paper makers, and will not be treated as a waste much longer. Richmond and others have shown conclusively that the Abacá waste is very easily reduced by alkaline treatments, and further that it bleaches readily and is suitable for paper of the very highest grades. The more general introduction of fiber-cleaning machines is certain to extend the manila hemp industry and to increase greatly the already large quantity of this waste available for treatment on the spot or for export. The yields of fiber on the hand-stripped waste are about 42 per cent, and on the machine-stripped about one-quarter less.

It is obvious that the fibrous raw materials which we have been considering require somewhat different treatment to meet their individual requirements and that they are in most instances too bulky for profitable transportation. The natural line of their development is, therefore, the manufacture of pulp and halfstuff upon the spot for trans-shipment to the mills of paper-consuming countries. The methods required are for the most part simple and well adapted for introduction into small local plants.

Use of Low-Pressure Steam from Compound Engines.

When power is produced by steam, only a small percentage of the total heat in the steam is utilized for power; a very large percentage goes to waste in the form of exhaust steam or in water of condensation. If low-pressure steam is needed for heating and manufacturing purposes, it can be used after it has passed through the engine and produced power, and its use in this manner is increasing constantly. It results in a large saving over taking steam direct from the boilers for heating and manufacturing purposes and allowing the heat which is rejected from the engine to go to waste.

If steam is used for power exclusively, the compound engine is the most economical type of engine to use for manufacturing purposes. If more or less low-pressure steam is required for other purposes than power, this type can also be used to advantage, except in such cases as require nearly the same amount of low-pressure steam as would be exhausted from an engine producing the amount of power required. In such cases as this the proper type to use would be the simple high-pressure engine.

Between the two extremes, of steam used for power only and an amount of low-pressure steam used equivalent to the whole amount exhausted from the engine, lie nearly all the cases of ordinary practice. The proper sort of engine to use in these cases is considered by Mr. Charles T. Main, of Boston, to be the compound engine from the receiver of which as much low-pressure steam can be taken as is required for the various heating purposes to which it is put, the remaining steam in the receiver passing into the low-pressure cylinder. The ratio of areas of the high and low-pressure cylinders is determined by the average percentage of steam exhausted from the high-pressure cylinder which is taken into the low-pressure cylinder.

As the amount of steam taken from the receiver is variable, the pressure in the receiver will be variable if the cut-off on the low-pressure cylinder is constant. As the practice of taking steam from the receiver for heating, drying and dyeing purposes is becoming more common, the necessity for maintaining a constant pressure in the receiver becomes more apparent. The method of fixing the cut-off on the low-pressure cylinder by hand to conform with the draught made upon the receiver is very unsatisfactory, requiring constant attention of the engineer, who is unable even with

close attention to maintain anywhere near a constant pressure in the receiver.

In order to maintain constant pressure in the receiver, Mr. Main devised the apparatus shown in the cuts, by which the cut-off in the low-pressure cylinder is automatically controlled by the pressure in receiver. The apparatus is successfully working on cross-compound and tandem engines and is applicable to the low-pressure cylinder of triple expansion engines.

The advantages derived from the use of regulator are: First, more uniform pressure in the receiver, insuring more uniform work in the operation for which the exhaust steam is used; second, in saving of fuel by reducing to a minimum the

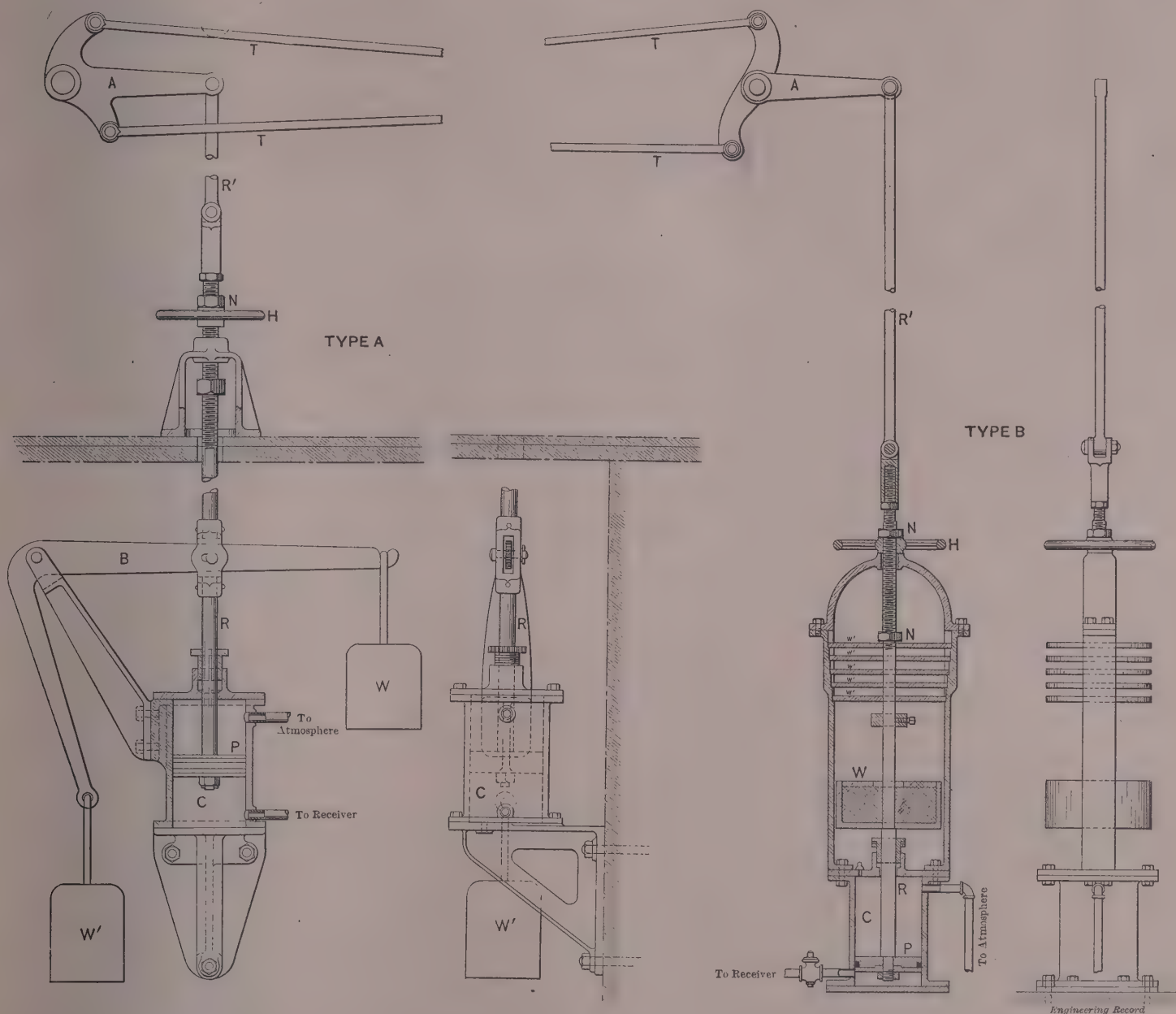
arm *B*, and on this arm are hung two weights, *W* and *W'*. When the pressure in the receiver increases it raises the piston and increases the cut-off in the low-pressure cylinder; when the pressure falls, on the other hand, the weights bring down the piston, thus decreasing the cut-off in the low-pressure cylinder.

The weight *W* determines the lowest pressure to be carried in the receiver, and the weight *W'*, as it swings from the vertical under-pivot, balances the variable pressure from the shortest possible cut-off to full stroke on the low-pressure cylinder. The hand wheel *H* is used to get a long cut-off when starting up the engine, and also to fix the minimum cut-off, or, if desired, to

the piston, thus decreasing the cut-off in the low-pressure cylinder.

The weight *W* determines the lowest pressure to be carried in the receiver and the series of weights *W'*, lifted one after another, balances the variable pressure from the shortest possible cut-off to full stroke on the low-pressure cylinder. The hand wheel *H* is used to get a long cut-off when starting up the engine, and also to fix the minimum cut-off, or, if desired, to run with a fixed cut-off. The nuts *N* and *N'* can be set to limit the range of cut-off.

Among the companies which are using this device are the following: Lower Pacific Mills, where receiver steam is used for dyeing, wool



Two Types of Receiver Pressure Regulators for Compound Engines.

blowing-off from the low-pressure system through relief valves, and the supply of high-pressure steam through reducing valves into the low pressure system. Two types of regulators were devised. All of these are in use and work equally well. Either type is used which best meets the conditions of any particular case.

In type A there is a small cylinder *C* in which is a piston, *P*. The receiver pressure is admitted to the cylinder below the piston. Above the piston the cylinder is open to the atmosphere. The piston rods *R* and *R'* connect with the arm *A*, and through this move the trip-rods of the valve gear *T* and *T'*. To the rod *R* is connected the

run with fixed cut-off. The nuts *N* and *N'* can be set to limit the range of cut-off.

For type B there is a small cylinder *C* in which is a piston, *P*. Above the piston the cylinder is open to the atmosphere. The piston rods *R* and *R'* connect with the arm *A*, and through this move the trip-rods of the valve gear *T* and *T'*. To the rod *R* is connected a weight, *W*. There is also a series of weights marked *W'* which are not connected with the rod *R*, but which are lifted in turn as this rod rises. When the pressure in the receiver increases, it raises the piston and increases the cut-off in the low-pressure cylinder. When the pressure falls, the weights bring down

washing, finishing and heating buildings; Warren Cotton Mills, a plain cotton mill where receiver steam is used for slashing and heating buildings; Arlington Mills, a worsted mill where steam is used for dyeing, etc.; Massachusetts Cotton Mills, in Georgia, a plain cotton mill where steam is used for heating and slashing; Massachusetts Cotton Mills, Lowell, a plain cotton mill, where steam is used for heating and slashing; Nonantum Worsted Co., a worsted mill, where steam is used for heating and dyeing; Stanley Works, where steam is used for heating and some other purposes; Dwight Mfg. Co., a plain cotton mill, where steam is used for heating and slashing.

Approximate Estimates.

Paper read before the Ohio Engineering Society, at Columbus, Feb. 12, 1908, by Alexander Potter, C. E., New York.

Misunderstandings and troubles have frequently arisen between engineers and contractors over the meaning of the term "approximate estimate," and a considerable number of law suits have resulted in which the exact meaning and use of this term have played an important if not a controlling part. According to the standard dictionaries, the words "approximate" or "approximately" seem to be clearly defined as something "close to in quality, degree, or quantity"; as something "nearly but not exactly accurate; as an approximate estimate; an approximate result"; as "very nearly but not absolutely."

In engineering work, when the quantity and character of the work cannot be absolutely and definitely determined beforehand, and competitive bids are required, the standard of comparison must be an approximate one. Bidders are invited to name prices per unit of measure, the quantities being given approximately only, to enable the contractor to determine at what price he will undertake a job of the size estimated, and it is customary to state in the invitation to bidders that the quantities named are approximate only. Now out of the different understandings of the meanings of this term "approximately only" have arisen the many disputes regarding claims for extra work, questions of fraud and misrepresentations on the part of the engineer, the interpretation of contracts in general, and of what constitutes balanced and unbalanced bids.

As the engineer is usually made the final arbiter of all questions arising under a construction contract, with power to make alterations, additions or omissions, and to determine the value thereof, the engineer's understanding of the meaning of the words "approximate estimate" becomes of the utmost importance, and some general rule should be adopted defining its meaning. Unless in engineering practice there is some well established rule to the contrary, the meaning of the word "approximate" must apply in engineering contracts and specifications which we find given in the dictionaries, i. e., that the engineer's estimates are "very nearly but not exactly accurate." The writer knows of no such rule in engineering as would warrant any other meaning being applied to this term in any of its connections.

We have already stated the purpose of an approximate estimate, viz: to obtain balanced bids for comparison in order to ascertain the lowest bidder upon any given piece of work. Unless, therefore, a uniformity of understanding as to the meaning of the word approximate exists, opportunity is afforded for misunderstanding between the parties, which, while it may be honest, is none the less troublesome and may work great injustice.

In the first place, many contracts are let under an erroneous impression as to who is the lowest bidder. It is assumed in many cases that approximate estimates are set forth simply for the purpose of canvassing bids and that the low bid is properly that one in which the summation of the items in the approximate estimate multiplied by the unit prices is less than all the others. This may or may not be true, and depends upon the accuracy of the approximate estimate. The truly lowest bid is that one in which the summation of items in the final estimate multiplied by the unit prices would have been the lowest. The necessity of accuracy and correctness in the approximate estimate is readily seen therefore. The main object in getting bids from contractors is not merely to determine who is lowest on the face of the returns, but to ascertain who will complete the work for the least amount of money.

Many engineers in advertising public work specify certain quantities of work to be per-

formed, but in the subsequent contract presented to the successful bidder for his signature carefully omit the quantities advertised as approximate so that they form no part of the contract. It needs no argument to set forth how unjust and unfair this may prove to be. The advertisement and proposal should always be made a part of the contract and specifications by specific reference thereto in the contract itself.

The powers and responsibilities conferred upon an engineer in connection with public work are often vastly greater than even the engineers themselves believe or realize to be the case. The importance of setting before the contractor proper and accurate data and estimates is something the engineer must not lightly consider. If the engineer has any thought that the specifications and estimates do not represent the actual future conditions, clauses should be inserted in the contract that will give the contractor the right to demand that, for unreasonable discrepancies, the work shall be paid for at cost plus a reasonable margin of profit. This may to a certain extent suggest an innovation in the manner of letting contracts, but I believe that it is the only fair and just thing to do and will in the end save not only trouble and litigation, but be a financial saving to the communities or companies adopting it.

Under the average specifications the engineer is not only a court of last resort and final arbitration, with powers of final decision specifically delegated to him, but he is also in reality the attorney for the defense, for the reason that he has either himself prepared all the important and vital clauses of the contract and specifications, or has inserted them from contracts which other engineers have previously prepared. It is customary for the legal representatives of the city or company letting the contract to have little to do with the preparation of technical contracts and specifications for construction work, merely passing upon the correctness of their legal form, and not at all upon their subject matter and requirements.

The engineer is also practically a defendant in matters of dispute arising between his employer and the contractor, because it is upon the correctness of his estimates that the work is based. On this account the tendency is very strong and the temptation very great for the engineer to endeavor to "make good" his estimates by minimizing as much as possible the difficulties met in the construction of the work by endeavoring to force the performance of work which had clearly never entered into the mind of the engineer or the contractor when the contract was signed. Had it been foreseen the contractor would never have taken the contract under the conditions specified, and the engineer, had he known of such conditions being present, should have forewarned the contractor or given notice of them in his approximate quantities.

The engineer having assumed the high duties of of judge, jury, defendant's attorney, and defendant in a court of last resort, should be a man of fearless justice, above suspicion or fear of himself, who will so write his specifications that he can with honor and fairness do right by both the city or company which employs him and the contractor who pleads for justice in his court. Until the engineering profession will rise to this high standard and condition it can never hope to stand where its mighty works should place it, not only a peer of the other professions, but on the top-most pinnacle of them all. In none of them is there a higher or a more urgent call for fearlessness, justice and fair dealing.

Contracts written with double or uncertain meanings, evasive clauses, or unjust and arbitrary assumptions of power, in the end bring no credit upon the engineer who writes them, nor profit to the corporation in whose favor they are enforced. There are of course allowable and unavoidable

variations in contracts and approximate estimates.

In the fabrication of steel, in the manufacture of machinery, and in the erection of the superstructures of buildings, there are but few and minor elements of chance which would interfere with a contractor giving such an intelligent bid that, provided his bid is a balanced bid, no harm can come either to the city or corporation or to himself by reason of a large discrepancy between the approximate estimate advertised and the amount of work which the contractor is called upon to actually perform, saving only the fluctuation in the price of labor and materials. But in all work involving the uncertainties of excavation of any sort, whether it be in earth, quicksand, or rock, such as is encountered in the construction of reservoirs and dams, water-works, sewers, railroads, canals, docks, or deep foundations, the actual cost of the work may differ very materially from what either the engineer or the contractor assumed the work would cost when the contract was entered into. The actual cost of removing earth and rock is in many cases from 50 to 200 per cent. greater than the engineer deemed at the time to be fair unit prices for such work. In other cases the actual cost of performance of work has often proved to be from 50 to 75 per cent. less than the price bid upon the work, which price was based upon the best information at hand at the time the bid was prepared.

Often, as the work advances, the actual conditions develop a state of things which proves that the information given in the first instance was entirely misleading. On this class of work, therefore, it is seen how important it is to have the approximate estimate of quantities approach the actual quantities which are to be required to be done as closely as possible, for if on the one hand the contractor has been led to believe that there is a certain amount of material to be handled and he is being greatly overpaid for the work performed, it is not fair to the city or corporation for which the work is being done, that it should be compelled to pay such excessive prices upon an amount greatly in excess of the advertised quantities and on which the contractor estimated his profits. While on the other hand, if the contractor has agreed to the performance of work at a price which is grossly inadequate, under the honest misapprehension of conditions, it is unfair, under the omnibus clause in the contract providing for variations, additions, and changes, to compel him to perform work greatly in excess of the quantities upon which he was willing to risk his judgment and his capital as to the value of work.

The limiting of the words "approximate estimate" to mean a quantity within a reasonable percentage above or below the amounts called for will tend to much more intelligent bidding, and also to the eradication and elimination of much of the trouble and litigation now occupying the courts of this country, due to the involuntary fraud upon or on the part of cities permitting or compelling contractors to perform work at absurdly high or absurdly low prices upon amounts which neither the engineer nor the contractor dreamed he would be called upon to perform at the time of the signing of the contract.

There should be no difficulty in inserting clauses in specifications providing that when the approximate estimate shall have been exceeded by a certain predetermined percentage, the unit prices bid upon the work shall no longer prevail, but that the balance of the work shall be performed at cost to the contractor plus a reasonable percentage for profit on labor and material.

Under the ordinary form of contract the engineer is now empowered to make any and such changes as he may see fit in the work. In other words, he is given such extraordinary powers of control over the contractor, that the contractor can hardly object to having delegated to the en-

gineer the determination of what this extra cost shall be; and the city or corporation having already placed in the hands of the engineer the responsibility of conducting its work, should have no objection to vesting him with this small additional power. The writer can conceive of no difficulties arising from such a restrictive clause as that mentioned, but believes that in the end the adjustment of all inequalities under the contract, and provisions for settling them would tend to lower the cost of contract work generally.

The question will of course arise as to what this limitation in the variation of each item over the approximate estimate should be. But this is not difficult to determine. Ideas will differ somewhat, but under the interpretation of the word as given in the dictionary, they can not differ to any great extent. In the writer's judgment there should not only be a limitation upon the gross amount of the contract, but also a limitation on each particular item of the estimate. The allowance of variance for any particular item would depend largely upon the factor of uncertainty involved and should never be greater than upon the total amount of the contract. On a single item there might be conditions of variation of as much as 50 per cent., while on the total amount of the contract the variation allowed should doubtless never be more than 20 per cent. without some readjustment of prices upon such a basis as that mentioned, viz.: that when the approximate estimate shall have been exceeded by a certain predetermined percentage, the unit prices bid upon the work shall no longer prevail, but that the balance of the work shall be performed at cost, plus a reasonable percentage of profit on labor and material.

AN ADHESION RAILWAY has recently been built from Clermont-Ferrand, France, to the summit of the Puy-de-Dôme, 3,100 ft. above the town, to accommodate tourist traffic up the mountain. The line has a total length of 14.8 miles and the maximum gradients are 1 in 8½; there are many curves with radii varying from 135 to 6,600 ft. The gauge is 1 meter and the rails weigh 50 lb. per yard. Ordinary steam locomotives are used, fitted with a special supplementary adhesion gear consisting of two pair of 3¼-in. horizontal wheels, one pair at each end of the locomotive, acting on a double-headed center rail which weighs 54 lb. per yard and projects 7 in. above the level of the other railheads. The locomotives weigh about 33 tons in full working order. The center rail is not continuous, but is broken for short distances at grade crossings and is unnecessary for considerable stretches where the grades are not excessive; in all about half the whole track is fitted with the third rail. The horizontal wheels are pressed on the middle rail by a system of levers operated by compressed air and the horizontal wheels are driven from the axles by chain belts and bevel gearing. The pressure of the wheels on the middle rail is adjustable and by an automatic device it is increased as the grade grows steeper and decreased on the level stretches. This device consists of a valve on the compressed air supply tank operated by a pendulum lever which assumes different positions as the inclination of the locomotive varies. Some of the advantages claimed for this adhesion system, according to "The Engineer," of London, are: The pressure of the wheels against the center rails is independent of any wear of tires or rails; the pressure is automatically adjusted according to gradient and can be further modified to suit the condition of the track; the device follows curves without tending to displace the center rail and is a safeguard against derailment. The cars are of the ordinary closed type designed to carry 40 passengers. Each car is fitted with a pair of horizontal wheels for braking purposes only, operated both by hand and by air.

The Development of the Mechanical Filter Plant.

A paper read before the Ohio Engineering Society by
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Special Assistant Engineer Ohio
State Board of Health.

The purification of municipal water supplies by mechanical filtration has achieved very rapid progress in the last few years, especially in Ohio, where there is now in operation at Cincinnati the largest mechanical filtration plant in the world, and at Columbus where there will soon be in operation the largest municipal softening plant in the world, and where the purification will be completed by mechanical filtration. It is the intention of this paper to indicate briefly along what lines the development of the mechanical filter from the early wooden tub to the modern concrete tank has taken place.

The first mechanical filters were used for industrial purposes where large volumes of water were required, and the treatment was perfectly satisfactory if a partial clarification of the supply was accomplished. It was not until the principle of coagulation by chemicals was applied to the preparation of the water for filtration that high efficiencies of bacterial removal were obtained.

The application of coagulants to water for clarification purposes has been used for many years. The coagulation of water with chemicals forms a gelatinous precipitate which not only subsides much more quickly than the suspended matters ordinarily contained in surface waters, but from its sticky gelatinous nature it has the faculty of collecting and carrying down the suspended solids with it.

The application of this principle to preparing the water for the mechanical filter developed the fact that an artificial schmutzdecke was formed on the surface of the sand by the coagulated masses, and that it was possible by the use of coagulants to obtain very efficient results with the mechanical filter, even at very high rates of filtration. With the continued use of the process there developed high efficiencies of bacterial removal and finally the application of the mechanical filter to the purification of municipal supplies.

In the following discussion it is endeavored to describe briefly the first types of mechanical filter plants installed, and then to show how various features have been modified in subsequent plants through a better understanding of their use.

A modern mechanical filter plant comprises four main features as follows: 1, a coagulant and a system for its application to the water to be treated; 2, storage of the water after the coagulant has been introduced and before it is applied to the filters; 3, filters; 4, storage of the water between the filters and the high service pumps.

The first type of mechanical filter consisted of a wooden tub varying in diameter from 8 to 20 ft., and from 7 to 9 ft. high. The filtering material comprised from 22 to 48 in. of coarse-grain sand of as nearly uniform size as possible. In the earliest types the collecting or strainer system consisted of a brass screen or perforated plate supported on a false bottom of wood about 12 in. above the bottom of the filter. The filters were washed by a reverse current of water applied at a rate of from 4 to 8 in. vertical rise per minute, and the sand was agitated during washing by revolving rakes carrying steel arms which extended down into the sand nearly to the bottom. No devices were provided to automatically regulate the discharge from the filters, nor gauges to show the loss of head that developed during their operation.

Little attention was at first paid to the preparation of the water applied to the filters. It was generally thought sufficient to allow a short time for the completion of the chemical reaction of the

coagulant on the water and the importance of sedimentation following coagulation was not recognized. The storage period allowed for the reaction varied from fifteen minutes to one hour.

The chemical most commonly used as a coagulant was commercial aluminum sulphate which was dissolved in tanks and the solution was either carried by gravity into the inlet to the coagulating basin or was applied by a small pump. In the Warren filter plant a small dipper pump driven by a revolving wheel in the low service main was used and proved very efficient.

Since the adoption of mechanical filters for the purification of municipal supplies, their improvement has been very rapid and has been due to changes in the design, materials of construction and the use of automatic devices for ensuring proper operation. In following through the development from the early mechanical filter plant to the modern type it will perhaps be best to discuss first the changes that have taken place in the filters themselves, following this by a discussion of the methods of preparing the water for the filters.

There are four elements in a mechanical filter as follows: The filter box or tank, the collecting or strainer system in the bottom, the arrangement of wash-water troughs, and the filtering material. There might be included also the mechanical devices provided to regulate the operation of the filter. All of these features are closely related and the design of one has considerable influence on the details of the others. They will, however, be discussed in the order above named.

The early filter tanks were constructed of wood and were round. Their shape was determined somewhat by economy of construction, but principally from the fact that revolving rakes were used to agitate the sand during washing. With the introduction of air agitation, which followed in about 1900, it was possible to use tanks of rectangular shape, which required less floor space and also permitted a better arrangement of the collecting system.

With the change in agitation came also a gradual increase in size from an average area of 177 sq. ft., corresponding to a one-half million gallon unit, to large rectangular tanks 1,400 sq. ft. in area and of 4 million gallons capacity, such as are used at Cincinnati. The construction of such large tanks has been made possible and economical by the recent development in the art of reinforced concrete construction.

The proper size of the filter units is governed largely by the total capacity of the plant. Until comparatively recently it was common practice to build them in one million gallon units, but in the large plants of recent construction the capacity of the units has been increased to 3 and 4 million gallons. The Columbus filtration plant comprises ten 3 million gallon units, while that at Cincinnati is composed of twenty-eight of 4 million gallons. In general it may be said that the larger the filter units, the greater the storage of water required between the filters and the high-service pumps in order to maintain the supply during such times as some of the filters are idle for washing or other reasons. There is considerable economy in construction and also greater ease of operation with large units, and hence their use in plants of large capacity.

After the size of the tanks has been determined the next feature to consider in the arrangement of a filter is the strainer system, the details of which offer perhaps more chance for originality on the part of the designer than any other one feature. The purpose of the system is two-fold; to serve as a collector of the filtered water, and also as a distributor of the wash water, and in proportion as the latter qualification is met is largely determined the success or failure of the filters.

The first form of strainer system, as previously

stated, comprised a brass wire screen or perforated plate supported on a false bottom. These screens soon proved unsatisfactory as they were easily broken or clogged, and from the large area of the openings provided did not give a good distribution of the wash water. The use of the filters soon developed the fact that it is necessary to have a controlling loss of head in the strainer system which shall offer such a large resistance in proportion to the total resistance offered to the inflow of wash water, that any unequal friction in the sand above the strainers has little effect on the distribution of the wash water. This requires a reduction in the total area of openings in the strainer system and the screens were soon replaced by a grid of small pipes into which perforated brass strainers were tapped at frequent intervals. At Harrisburg, Pa., a very satisfactory strainer system is in use in which the necessity for the perforated strainers has been avoided by placing the perforations in the bottom of the lateral pipes instead of in the top, as was first considered necessary.

In order to make the construction as durable as possible, it was common practice to use brass pipes for the laterals, and as this was expensive the strainer system sometimes cost over \$2 per square foot of filter area. It was largely to reduce this cost that the use of concrete channels covered by brass plates was next tried. This method has been found not only to decrease the cost of construction but also to provide the additional advantage that the plates are easily removed in case of obstruction by growths or any other cause.

The strainer system at Cincinnati is a good illustration of this type of construction. The filter bottom contains concrete channels 1 ft. center to center and the area of these channels is approximately 8 sq. in. They are covered with removable brass plates which contain perforations with an aggregate area such that the loss of head at the strainers during washing is very nearly 5 ft. This large loss of head insures a good distribution of the wash water no matter what the condition of the sand in the filter.

Another advantage in the use of concrete is that it offers a means of constructing the bottom of the filter in such a shape as to avoid dead spaces between the points of application of the wash water where growths of bacteria might accumulate. This is accomplished at Cincinnati by separating the strainer plates by concrete ridges.

Having described the methods of applying the wash water, it is next necessary to consider the means provided to remove the dirty water from above the sand. With the early wooden tubs of the New York and Jewell type, this is accomplished by allowing it to overflow over the top of the filters into an annular space provided between the filter proper and the settling tank, the sides of which are extended above the top of the filter tank. In the Warren filter annular metallic troughs are provided around the inside of the filter tank, and the wash water overflows into these troughs and is removed by connections to a drain. These methods of removing the wash water are fairly satisfactory although the center of the filter does not wash so rapidly as the sides, as there is less agitation at the center from the fact that the lineal velocity of the revolving rakes is less; moreover, the horizontal distance that the wash water has to travel is greatest at the center. With the use of rectangular concrete tanks it is possible to provide a more efficient system of gutters.

Practice has developed the fact that the proper washing of the filter is of the greatest importance in obtaining efficient results, and that in order to obtain a proper distribution of the wash water it is necessary that the troughs be of sufficient size and not too far apart. If the troughs are too

small they are flooded in the back portion of the filter farthest removed from the drain, and if placed too far apart the wash water from that portion of the filter farthest from the gutter has to travel too great a distance horizontally, allowing a deposition of some of the suspended solids. The maximum horizontal distance traveled by the wash water should not be greater than $3\frac{1}{2}$ ft. and the troughs should not be more than 7 ft. apart.

One of the chief causes of the many failures of the gutters provided in mechanical filters to remove the wash water is the fact that in figuring their capacity engineers neglect to provide sufficient gravity head to allow the water flowing into the gutters to obtain an initial velocity and only sufficient head is provided to keep the water in motion in the troughs after it has acquired an initial velocity. The velocity head is the ruling factor in the design of gutters, and economy of section requires as deep a gutter as possible.

This principle was considered in the design of the gutters in the Cincinnati filters. Each of these gutters is 14 in. wide with a maximum depth of 21 in. They are 14 ft. long and will each carry about 4.2 cu. ft. per second at a maximum velocity of not far from 4 ft. per second. With the shallow gutters frequently provided in filters the maximum velocity is generally not greater than 2 ft. per second.

There have been several changes in the methods of agitation applied to assist in washing filters. Mechanical rakes were first used, and in general have proved satisfactory for small tanks. With the larger rectangular tanks, air under a pressure of about 5 lb. per square inch is sometimes applied, and proves satisfactory when properly handled. It is introduced either in a separate system of small perforated pipes or into the strainer system direct. Either arrangement accomplishes practically the same result, although the second requires a less first cost.

In the preliminary experiments at Cincinnati it was learned that air agitation was unnecessary and that the best results were obtained by applying the wash water at higher rates than those in common use, namely 8 to 12 in. per minute. The Cincinnati plant is designed to permit of an application of the wash water at a rate of 30 in. rise per minute and no other agitation is provided. The rate actually used at Cincinnati is about 25 in. per minute and the sand in the filter is lifted 24 in. during washing and is so thoroughly scoured by the water that but 2 minutes' application is required to wash the filter. With the slower rates of application and mechanical agitation the length of time required to wash a filter varies from 8 to 20 minutes, depending on the preparation of the water for filtration and the quantity filtered between washing.

Just as there has developed a greater appreciation of the necessity for an economical and efficient washing system, so has there developed a feeling that the actual size of the filtering material used is not as important as was at first thought. The sand first used was of a coarse grade and as nearly uniform size as possible, and cost perhaps \$5 per ton. Modern practice permits the use of ordinary river sand, washed and screened, of somewhat less uniform size and costing perhaps \$2 per ton. If the material actually provided proves to be too fine it is possible by a judicious use of wash water and an occasional scraping to increase its size, and, if too coarse, more fine material is easily added. It is found that too great a proportion of fine material gives too large an initial loss of head, while if the material is too coarse the effluent from the filter immediately after washing is unsatisfactory.

In general the specifications for filtering material are now much less rigid than they used to be, as the sand is easily graded by the wash water after placing in the filter. Modern prac-

tice now requires the use of sand having an effective size of about 0.35 mm. and a uniformity coefficient of 1.3 to 1.6.

Before concluding the discussion of the development of the filter, brief mention will be made of the methods now in use for controlling their operation. The valves of the first filters were all hand-operated and no automatic devices were provided to maintain a constant rate of filtration nor loss of head gauges to indicate when washing was necessary. For economical reasons it is desirable to maintain the rate of filtration at as nearly the maximum efficient rate as possible, and also to make the period of time between washing as long as possible.

The early automatic rate controllers are of the open type, and depend on the automatic control of a hinged valve by a float, generally contained in a small open tank. These controllers are efficient but require that all the available head on the filter shall be above the controlling valve, and moreover, the loss of head in the controllers themselves is sometimes as great as 2.5 ft. In order to avoid this loss of head and to decrease the lift necessary to pump the water to the filters, closed controllers are now sometimes used and their principle of operation depends on maintaining a constant head on a fixed orifice by means of a balanced valve.

In order to maintain the longest possible period between washings, it is necessary to know just when a filter is dirty, and gauges are now used to show the difference between the static head of water on the filter and in the effluent pipe. When this difference reaches the maximum head allowed the filter is washed. These gauges are of use also as indicating the initial loss of head in the filter, and the degree to which the filtering material is cleaned.

With large plants economy of labor necessary for operation requires that some auxiliary power be provided to operate the regulating valves, and also that this power be applied from a central point of control. This is accomplished either by the use of hydraulic valves operated from a stand, or by electrically operated valves the motors of which are controlled from a central switchboard. The former method is in more general use, but the latter is provided at Cincinnati, where no water is available under sufficient pressure to operate hydraulic valves. The efficiency of the automatic devices provided at the Cincinnati plant may be estimated from the fact that a single attendant may easily operate the filter house, the capacity of which is 112 million gallons per day.

In the above discussion it has been endeavored to indicate briefly the development that has taken place in the filters themselves, and the changes next considered will be in the preparation of the water before it is applied to the filters. This preparation includes the application of a coagulant and a storage of sufficient time to allow both a completion of the chemical reaction of the coagulant and a partial deposition of the coagulated masses.

Until 1900 the only coagulant in general use for mechanical filter plants was commercial sulphate of aluminum, commonly called "filter alum." Since 1900 copperas or sulphate of iron applied together with lime has come into favor as a coagulant, and is now in use at many filtration plants, among which may be mentioned five in Ohio. The copperas in general use is sold by The American Steel & Wire Company and as it is a by-product for which there is but a limited demand it is sold at about one-half the price asked for alum. It is not the intention of this paper to discuss the relative merits of copperas and alum as coagulants, but a brief statement will be made of a few of the facts that have developed during the recent special investigations of water purification plants in Ohio by the State Board of Health.

The use of alum requires merely that there be sufficient alkalinity in the treated water to insure its decomposition and removal, and in order to accomplish this it is sometimes necessary to introduce also a small quantity of lime. The successful use of copperas and lime requires an accurate adjustment between the two coagulants, as the use of too little lime gives a poor coagulation, and the use of too large a quantity causes the formation of "after deposits" in the filters. Such deposits have caused considerable trouble at Marietta, and in both the old and new filter plants at Lorain.

It has frequently been stated that, other conditions being the same, less copperas than alum is required to give the same efficiency of removal in the coagulating basins. This statement has not been borne out at Lorain, particularly in the new plant, where it has been impossible to obtain continually satisfactory results using copperas, and in a recent official test of the plant, using approximately 2 grains of copperas, the average efficiency of bacterial removal by the coagulating basins was but 39 per cent. In a subsequent official test approximately 2.5 grains of alum were applied and the efficiency of the coagulating basins was increased to 81 per cent. The experience at Lorain would seem to indicate that Lake Erie water is better coagulated using alum than using copperas, and that the application of alum is much more easily accomplished. At Cincinnati, the use of copperas and lime appears to be very satisfactory, and it is apparent that the best results in coagulating water are not to be obtained by an indiscriminate use of either coagulant, but by a study of the character of the water to be treated, and by proper design and arrangement of the plant.

In regard to the effect of the coagulants on the water treated, the use of alum produces a more sparkling water and the change in hardness brought about consists in converting a part of the temporary hardness into permanent hardness, while with the application of lime and copperas there is an addition of approximately 0.5 grain per gallon of total hardness for each grain per gallon of copperas applied. This latter statement is on the assumption that lime is not applied in excess.

Not only does the alum produce a more brilliant water, but it removes a much larger percentage of dissolved color, so that its use is necessary for the satisfactory treatment of a highly colored water.

In general it may be said that there appears to be but one recommendation for the use of copperas as a coagulant, and that is its less first cost, which is, however, offset by additional difficulties and expense incurred in its application. Unfortunately, comparative figures that have been published on the use of the coagulants have been based on the first cost of the chemicals and not on the total operating expenses of the plant.

As previously stated, the original method of applying the coagulant and one which is now in common use in small plants, consists in dissolving weighed charges of the chemical in storage tanks where the solution is kept until used. It is pumped or flows by gravity into the raw water, and its application is varied by changing either the strength of the solution or the rate of its application. While this method of handling the coagulant is satisfactory for small plants, at St. Louis and Cincinnati, where the quantity of coagulant used is very large, amounting to several tons a day, the room required for the storage of the solution would be very great, and at St. Louis was developed a method of direct application of the coagulants without storage. This is accomplished by introducing a constant weight of the dry chemical at stated short intervals of time into a tank, through which a constant stream of water is passed upward. In this procedure there soon

develops a condition that the quantity of chemical carried away by the water is equal to that introduced, and the solution maintains very nearly a constant strength. The quantity of coagulant applied to the water is very easily varied by changing the interval of time between the application of the charges. This method of dissolving the coagulant also eliminates the necessity for pumping the solution, as it is carried by gravity to its point of application, which is generally near the entrance to the coagulating basins.

That part of the filter plant that has been least appreciated is the coagulating basin, and in the plants of early design the basins have a very limited capacity and were provided merely to give storage for the completion of the chemical reaction without any subsequent sedimentation. The removal of the suspended matters in the water is all accomplished by the filter, and when the raw water is dirty the sand rapidly clogs and it is necessary to wash the filters at frequent intervals so that the wash-water used is sometimes over 30 per cent. of the quantity filtered. At such times also it is necessary to use very large quantities of coagulant.

With the use of concrete construction, the capacity of the coagulating basins has been increased from one to three hours and finally at Harrisburg and Cincinnati to about five hours, and they effect both coagulation and sedimentation. This large increase in the capacity of the coagulating basins causes not only a greater ease of operation, but a great improvement also in the efficiency of the results obtained.

Just as a bridge engineer would not design a structure for the average, but for the maximum load, so should a filter plant be designed for the treatment of the worst water that it is required to purify. While three hours' sedimentation after coagulation is perhaps sufficient for treatment under average conditions, the frequent occurrence of periods of high turbidity in the raw water requires that a longer period of sedimentation be provided in order to secure economical and efficient results at such times. Moreover, the changes in the character of the raw water require changes in the period of coagulation and sedimentation provided. This has been accomplished at Harrisburg by providing two basins and two possible periods of coagulation, varying from 30 minutes to five hours, and at Cincinnati, where three basins are provided and the time of coagulation and sedimentation may comprise any one of the following periods, 0.4, 2.1, 2.6, 4.3, and 4.7 hours.

The economy of providing a secondary application of the coagulant has not been appreciated until recently. Highly turbid waters which require large quantities of coagulant absorb and render inactive sometimes even 75 per cent. of the total quantity of coagulant applied. This fact has been appreciated in some of the most modern plants, where it has been recognized that, if sufficient sedimentation is provided, the greater proportion of the suspended matters in the raw water may be removed either by plain sedimentation, or by sedimentation following the application of a small quantity of coagulant. This is followed by the application of a second quantity of coagulant, perhaps one hour before the water is applied to the filters.

In general it may be said that the satisfactory treatment of the water for filtration requires that its turbidity shall be reduced to not greater than 50 parts per million, and that if sufficient sedimentation is provided this may always be accomplished by the use of a small quantity of coagulant. Flexibility in the period of sedimentation allowed and the provision of at least two points for the application of the coagulant, while requiring a greater first cost of construction, permit of much greater ease of operation and better and more economical results.

The last unit of the mechanical filter plant to be considered, namely the storage of filtered water between the filters and the pumps, requires but little discussion although much of the difficulties of operating plants of early design are due to inadequate provision for storage of filtered water at the plant. The period of storage allowed is sometimes not greater than 10 minutes' operation of the pumps, and it is found practically impossible to maintain the filters and pumps at the same rate, and it is also sometimes necessary to run the filters very fast immediately after washing. This is particularly true when direct pumping is used without a distributing reservoir, and in such plants the storage period provided should not be less than two hours. When a plant is operated at its full capacity it is impossible to obtain satisfactory results without a sufficient storage in the clear well, even with a distributing reservoir, and the minimum working storage allowed at any plant should not be less than one hour, and preferably at least two hours.

While it would be desirable to include in this paper a statement of the costs of installation and operation of mechanical filter plants, there are so many features to be considered that it is impossible to include more than a few general statements.

The filter plants of early design comprising tanks of wooden construction cost from \$3,000 to \$8,000 per million gallons capacity, and their operation costs from \$3 to \$12 per million gallons, depending on the capacity of the plant, the character of the water treated, the quantity of coagulants and fuel necessary, and the cost of labor required for operation. With concrete construction, the cost of installation is greater and averages about \$13,000 to \$16,000 per million gallons capacity. The cost of operation may be kept down to a low figure, as is well illustrated at Harrisburg, where the average cost of filtering each million gallons during 1906 was but \$4.76, including \$1.40 for coagulant. The cost of labor, \$1.98 per million gallons, will decrease in subsequent years as the quantity of water filtered approaches the ultimate capacity that the plant can handle.

The bacterial removal that may be accomplished by a well designed and operated mechanical filter plant is also well shown at Harrisburg, where the average bacterial removal by the plant during 1906 was 99.24 per cent. of the bacteria in the river water. This was accomplished with the use of an average quantity of but 0.95 grain per gallon of alum and but 2 per cent. of wash water.

In conclusion it should be said that the use of the mechanical filter has long since passed the experimental stage, and that it has proved very efficient and economical for the purification of turbid waters such as are found in the middle West. The installation of such plants has generally been followed by an improvement in the general health of the community, and the satisfaction of having a clear, wholesome water supply has more than repaid any expense incurred by the installation and operation of the filter plant.

A BRIDGE ACROSS THE BLUE NILE at Khartoum was contracted for recently by the Soudan Government Railway system, the order being placed with the Cleveland Bridge & Engineering Co., Ltd., of Darlington, Eng. It will consist of seven fixed river spans, each 218½ ft. long, and one rolling lift span of 111 ft. 9 in., making a length over the waterway of 1,641 ft. 3 in. In addition there will be four short approach spans. It will carry two 3-ft. 6-in. gauge railway tracks, a roadway and a 11-ft. footwalk, the latter carried on brackets outside the trusses, which are to be 38 ft. 3 in. apart. The trusses will be carried on steel cylinders, 16 ft. in diameter at the cutting edge, 11 ft. at the top, the cutting edge reaching a depth of 60 ft. below the water level.

Book Notes.

An unusually interesting compilation of municipal statistics has recently been published by the Seattle Real Estate Association. It is entitled "Reports on City Real Estate Values" and consists of information from 48 cities, giving estimates of the range in value of real estate, the value of different kinds of property according to their uses, street railway fares, taxation, water rents, rentals, and net incomes from improved property.

A pamphlet that deserves careful attention has recently been issued by the Independent Asphalt Association, 90 West St., New York. It is entitled "The Control of Street Openings" and is made up of information derived from many sources concerning the needless destruction of pavements by constantly tearing them up for one purpose or another. The information is not only obtained from standard works on roads, streets and municipal conditions, but also from letters on the subject sent directly to the Association by engineers of many cities. The pamphlet closes with the suggestion that the remedy lies in passing new laws which shall require individuals, public service companies and city departments to obtain permits and make deposits in a prescribed manner for all proposed openings.

The demand for the "Geological Map of Illinois" issued a short time ago has already exceeded the number of copies that were printed, and a second edition has just been published by the State Geological Survey at Urbana. A large number of corrections have been made in the map and in the accompanying text, so that their value has been considerably enhanced. The shipping coal mines are indicated, as are the lead, zinc and fluorspar producing localities, as well as the producing oil pools. No attempt has been made to show the scattered occurrences of oil and gas in the State, but as these are now being investigated carefully it is not unlikely that some of them will be shown on the next edition of the map. In the present edition the alluvial bottom lands along the more important rivers of the State are shown and the line separating the upper and lower coal measures has been omitted, as it has been found of slight utility in interpreting the geology of the State.

The 25th annual issue of the "Statistical Tables" issued by Spencer Trask & Co., New York, has just appeared. This booklet of 84 pages summarizes the more important information relating to the financial status of American railway and industrial companies. The pages devoted to statistics of railways give the average mileage operated, capitalization, dividends and dates of payment, gross and net earnings, fixed charges and the range in the price of stocks during 1907. About the same information is given concerning street railway, electric light and industrial companies whose securities are listed on the New York Stock Exchange. The statistics of railways bonds show the amount outstanding, rate of interest, interest dates, number of miles upon which the bonds are issued, and the high, low and last prices in 1907. There are also several pages explaining what stocks are cumulative or non-cumulative as to dividends and also the amount of dividends to which preferred stocks are entitled, and whether or not they are also preferred as to assets.

In a book entitled "Analysis of Elastic Arches," Mr. Joseph W. Balet sets forth principally a graphic method he has developed, largely based on the work of other investigators, into the properties of masonry, concrete and steel arches. He makes use of what he terms "intersection

loci" and "tangent curves," the former of which he modifies to suit special conditions of profile of the arches considered. The book requires most careful reading and is better adapted for use by an engineer already familiar with arch designs than by a beginner. The author has evidently given the subject much study and deserves credit for his investigations, but it is something of a pity that he has not arranged his explanations of methods and their applications so as to obviate constant reference to subsequent pages. Several useful tables are given, relating to existing arches, formulas for safe stresses in members, loads on bridges, impact coefficients and other subjects. The appendix contains the mathematical analysis of the elastic arch which the author believes most satisfactory. He states that he has followed Winkler, Mueller-Breslau, Melan and others. There is still so much to learn about this subject and investigators in the field differ so widely about many points, that it cannot yet be said that the last word has been uttered in this addition to the literature of arches. (New York, Engineering News Publishing Co., \$3.00).

Letters to the Editor.

A PROBLEM IN HYDRAULICS.

SIR: In your issue of Nov. 30 is given a solution of a hydraulic problem which undoubtedly is of great interest to many. This problem was

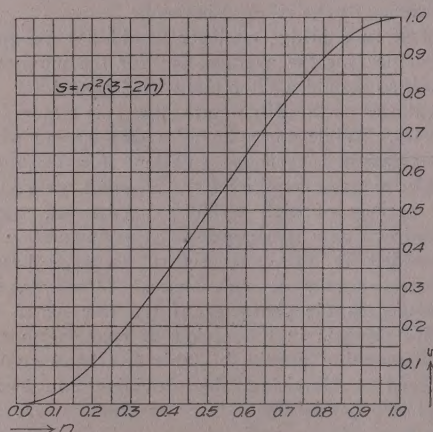


Diagram for Wood Floats.

to determine the exact distance to which a wooden ball would sink in water. Another solution of it is given below, which I find to be considerably shorter and more practicable, in that the curve in the diagram, after having once been plotted, can be applied to determine the distance that a ball of any diameter will sink, its specific gravity being known.

The curve gives the ratio of the immersed depth of the ball to all specific gravity values from 0 to 1. Let d be the diameter of the sphere; s the specific gravity; W the volume; V the volume of the segment of the sphere under water, or the displaced water.

When there is equilibrium, $sW = V$ or $s = V/W$. But $V = \frac{1}{6}\pi n (3r^2 + n^2)$ (Simpson's formula) and $r^2 = n(d-n)$ or $r^2 = n(1-n)$, where n is the depth of submergence of the sphere, and r is the radius of the circle cut on the sphere by the surface of the water.

$$V = \frac{1}{6}\pi n^2 (3-2n)$$

$$W = \frac{4\pi}{3} \left(\frac{d}{2}\right)^3 \text{ or } W = \frac{1}{6}\pi.$$

Substituting these values of V and W in the equation $s = V/W$, we have

$$s = n^2 (3-2n).$$

In the diagram in which this equation is plotted the values of the diameter are given as the abscissas, and those of the specific gravity as the ordinates.

If $n = 0$, then $s = 0$, in which case no part of

the sphere will be under the water; again, if $n = 1$ then $s = 1$, and the whole sphere will be under water.

The following example will illustrate the use of the curve: Given a wooden ball of 12-in. diameter and specific gravity (s) 0.844, to find value (n). For this value of s in the diagram we find the corresponding value of n to be 0.75 about, which multiplied by the diameter, 12 in., equals 9 in., or the depth of the ball under water.

Very truly yours,

Minneapolis, Feb. 13.

A. G. JETTE.

TESTS OF TINY-VISINTINI BEAMS.

SIR: In view of the report by Mr. Burroughs in your number of Feb. 1 concerning a test of a reinforced concrete floor slab in this city, you may be interested in another test made here on Dec. 7, using three Tiny-Visintini beams, a type of open lattice reinforced concrete beams too well known to need description. Each beam was 25 ft. long, 12 in. deep and 12 in. wide. The upper flange was $3\frac{3}{8}$ in. thick and reinforced by two $\frac{1}{2}$ -in. medium steel rods, the lower flange was $2\frac{7}{8}$ in. thick and reinforced by two 1-in. rods, and the diagonals were 1 in. thick and reinforced by two $\frac{1}{2}$ -in. rods. The concrete was a mixture of one part Golden Gate Portland cement, $1\frac{1}{2}$ parts of sand and $3\frac{1}{2}$ parts of gravel. The three beams were supported side by side on two brick piers which raised them about 3 ft. above the ground, and the joints between them were filled with 1:1 cement mortar. The beams were made ten weeks previous to the test, and their dead weight was 94 lb. per square foot of top surface. They were figured for a live load of 125 lb. per square foot.

The test was made by spreading sand over the top surfaces of the three beams, to a depth of 10 in., and on this a layer of sand bags was placed, bringing the load to 127 lb. per square foot. The deflection at the center of the clear span of $23\frac{1}{2}$ ft. was not quite $\frac{1}{4}$ in. This load was left in place 6 days without causing any further deflection, after which pigs of lead were added slowly, deflections being read from time to time. At 258 lb. per square foot the deflection was $\frac{1}{2}$ in., at 405 lb. it was 1 in. and at 590 lb. it was $1\frac{1}{2}$ in. and cracks appeared in the brick piers. The first cracks appeared in the middle of the lower flange, when the load was 714 lb. per square foot and the deflection $2\frac{1}{2}$ in. When the load reached 763 lb. two of the beams were subjected to a heavier load than the third, owing to an unequal distribution of the pig iron. This caused two of the beams to deflect more than the third, and about six-tenths of the load slid off as a consequence. The permanent deflection of these beams was $3\frac{3}{4}$ in. while that of the third beam was $1\frac{3}{4}$ in. The test was made for the Concrete & Steel Engineering Co., 410 Kearny Street, San Francisco, which is introducing this system of construction on the Pacific coast.

Very truly yours,

San Francisco, Feb. 10.

G. J. MILTON.

THE PRODUCTION OF WOOD POLES for telegraph and telephone lines, electric light and power systems, street railways and railroad companies during 1906 was 3,575,000, valued at \$9,471,000. These figures do not include poles less than 20 ft. long. Cedar poles were used most and chestnut ranked second. Owing to the growing scarcity of the supply of timber for such purposes, the American Telephone & Telegraph Co. is carrying out extensive experiments in cooperation with the U. S. Forest Service to determine the best methods and materials for preserving these poles. Several experimental lines of variously treated sticks have been erected and a careful record of the behavior of each pole is being kept. The comparatively new open-tank treatment has apparently been of much service in affording a means of lengthening the life of poles without too great expense.